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AIRWORTHINESS OF THE DC-10

HEARING

BEFORE THE

SUBCOMMITTEE ON AVIATION

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

ON

AIRWORTHINESS OF THE DC-10 AIRCRAFT

SEPTEMBER 19, 1989

Printed for the use of the
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AIRWORTHINESS OF THE DC-10 AIRCRAFT

TUESDAY, SEPTEMBER 19, 1989

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON AVIATION,
Washington, DC.

The subcommittee met at 9 a.m. in room SR-253, Russell Senate Office Building, Hon. Wendell H. Ford (chairman of the subcommittee) presiding.

Staff members assigned to this hearing: Carol Carmody, professional staff member; Steve Palmer, senior professional staff member; and John Timmons, minority staff counsel.

OPENING STATEMENT BY SENATOR FORD

Senator FORD. Good morning, ladies and gentlemen.

The purpose of today's hearing is one of reassurance, reassurance for this subcommittee and this senator that the Federal Aviation Administration is doing its job in areas of regulation and certification of aircraft; reassurance to the flying public that they can fly the DC-10 safely.

Since the Sioux City accident this summer, which involved a DC-10 aircraft, I have had dozens of people ask me, and I quote, "Why are those planes still flying after having so many problems?" end of quote.

Now, these are not engineers making this statement; these are just ordinary people who fly occasionally, and who, based on what they see and hear, have real concerns about the safety of the aircraft.

Since the DC-10 was introduced into commercial service, there have been a number of tragic and highly publicized accidents involving the aircraft. Speculation among laymen centers around the wisdom of having an engine in the tail and the location of the hydraulic system, and so forth.

Groups, like the International Airline Passenger Association, who sought the grounding of the aircraft in 1979, are asking again that it be taken out of service until it is fixed.

Admiral Busey, the Administrator of the FAA, has replied to these requests by insisting that the aircraft is safe, and has refused to ground it based on current evidence.

I am very pleased to have the Admiral here today to address these concerns directly.

Since the Sioux City accident, the FAA has established a joint task force with the industry to explore ways to survive catastrophic failures in wide-body jets. As I understand it, it is the same kind of

task force which was assembled to study the issue of aging aircraft after the top of an Aloha jet peeled off. That task force has been very productive. Let us hope this one will be, too.

I know everyone here is concerned with the same thing: maximum safety. And I know that men are not gods and cannot predict everything that could happen to an aircraft. It seems that I have heard after every major accident, "This is a one-in-a-million happening. Nobody ever thought this kind of damage would occur."

But knowing all of that, I also believe that the regulators and the manufacturers have to plan for the unlikely, the unexpected and the near impossible. They have to keep their minds open to new designs and improvements. They cannot respond to the fears of the public by pat assurances that flying is the safest way to travel. It may well be, but the horror of a major crash splashes across newspapers and television, and frightens people in a way that an automobile accident does not.

So I look forward to the testimony today from the experts. I urge them to keep working on ways to improve safety. I ask them to keep us informed of their progress on the investigation of the Sioux City accident. And I expect them to use all the resources at their command to assure that older planes are airworthy and that new productions incorporate the safest technology available.

I am very pleased to have the ranking member here this morning, Senator McCain.

Senator, do you have a statement.

OPENING STATEMENT BY SENATOR McCAIN

Senator McCAIN. Thank you, Mr. Chairman. And thank you for holding this hearing. I think it is an important one.

I think the issue, as you described it, is certainly one which is of great concern to the American public. And I think it is also worthy of note that polling data indicates that there is a growing lack of confidence in airline safety on the part of the American people. And a great deal of that concern is centered about the DC–10 aircraft.

As you mentioned, it is well known that it is safer to fly, statistically, on an airliner than it is to travel on the highways. But that is not the perception out amongst the American public. And I think this hearing may go a long way towards providing the reassurance that clearly is needed at this time.

Mr. Chairman, I am a frequent flyer, as most of our colleagues are, and I have had occasion to fly the DC–10 quite often. And from the information I am familiar with, I must state that I have confidence in that aircraft. The statistics I have seen indicate that the DC–10's safety record is on a par with other wide-body aircraft.

However, this does not mean we should rest on our laurels; we should continue the learning process throughout the life of every aircraft type. And this does not in any way minimize the issue of aging aircraft throughout the industry, which I know has been a subject of concern to you and the subcommittee and will continue to be.

We should not hesitate to bring these lessons into the field and make modifications where appropriate. The FAA has a number of

initiatives underway, which I applaud and encourage, which we will hear about this morning.

The aging aircraft task force has produced good results. In addition, Admiral Busey has formed a group to examine how wide-body aircraft survivability can be improved in cases of severe structural damage.

I have confidence that the FAA, under Admiral Busey's leadership, will rapidly and satisfactorily address these and any other safety issues that confront us.

I would also like to make note of the prompt action on the part of McDonnell-Douglas, and General Electric, the manufacturer of the engine that failed in the United 232 case. McDonnell-Douglas has announced modifications designed to prevent total hydraulic failure if future catastrophic engine failures occur.

It is regrettable, I might add, that it took an accident of that size before that action was taken. Mr. Chairman, we can never totally eliminate the element of risk from flying; we can minimize it. And I look forward to testimony from those both in and out of government who are charged with this task.

Thank you, Mr. Chairman.

Senator FORD. Thank you, Senator McCain.

I have an opening statement that Senator Kasten would like to have included in the record.

[The statement follows:]

OPENING STATEMENT BY SENATOR KASTEN

Mr. Chairman, after the Sioux City, Iowa crash just 2 months ago today, I commend you on calling this hearing to examine what we now know, and more importantly, what we have learned from that disaster.

I am pleased that we will be hearing from FAA Administrator Busey, the NTSB, and a representative of McDonnell Douglas, the manufacturer of the DC-10 aircraft.

Though the DC-10s have had other accidents, the total loss of hydraulic power experienced after the engine of the airliner blew apart has resulted in a planned retrofit by McDonnell Douglas. New operational procedures and inspection protocols are also being studied. Because of the catastrophe in July, it is important that we understand the response of both the government and the private parties to assure that this type of failure has been corrected to the greatest extent possible.

Again, I commend you for holding this hearing in quick order after the accident of 2 months ago.

Senator FORD. Our first witness will be the Hon. James B. Busey, Administrator, Federal Aviation Administration.

Admiral, if you will identify the gentleman with you, we will proceed. You may make your opening statement.

STATEMENT OF HON. JAMES B. BUSEY, ADMINISTRATOR, FEDERAL AVIATION ADMINISTRATION, ACCOMPANIED BY ANTHONY BRODERICK, ACTING EXECUTIVE DIRECTOR, REGULATORY STANDARDS AND COMPLIANCE

Mr. BUSEY. Thank you, Mr. Chairman.

The gentleman accompanying me is Mr. Tony Broderick, who is the acting Executive Director for Regulatory Standards and Compliance in the FAA; a gentleman whom I consider my expert in the issue of regulation and certification in that field.

Senator MCCAIN. Is this your first official appearance before the subcommittee, aside from your confirmation?

Mr. BUSEY. Yes, Senator McCain, it is.

Senator McCAIN. Welcome.

Mr. BUSEY. Well, Mr. Chairman, with your permission, I will submit my full prepared statement for the record and just briefly summarize my comments at this time.

Senator FORD. You have learned fast, Admiral. Your full text is accepted and your brief outline we will look forward to.

Mr. BUSEY. Thank you, sir.

I welcome the opportunity to appear in my first session before the subcommittee to discuss with you actions the FAA has taken previously to respond to problems which have arisen with the DC-10, as well as steps we are taking now to address the concerns arising out of the recent Sioux City accident.

At the outset, I would like to assure you and the public that the DC-10 is a safe aircraft and that we have no safety information in our possession at this time which would cause us to consider grounding the aircraft.

The DC-10 is perfectly safe to fly.

The DC-10 has been operating since 1971. During that time, the DC-10 fleet, of which 446 were built, which includes the U.S. Air Force KC-10 aircraft, has logged more than 5 million landings and more than 15 million flight hours. Of the 17 DC-10 aircraft which have been destroyed in accidents prior to the Sioux City accident, only one accident, the crash of a Turkish Airlines DC-10 near Paris in 1974, appears to the FAA to involve a design deficiency that clearly played a significant part in the loss of that aircraft.

The Turkish Airlines tragedy involved the loss of a cargo door and subsequent loss of aircraft controls. The separation of the cargo door from the aircraft resulted in depressurization, which collapsed the aircraft floor, impacting control cables which ran under the floor.

Following the Turkish Airlines accident, the FAA took action to resolve the cargo latching door problem and to deal with the issue of floor strength for all wide-bodied aircraft.

A number of other corrective actions were taken after the DC-10 crashed on take-off at O-Hare Airport in 1979, 10 years ago. This accident was precipitated by the separation of the left engine and pylon from the aircraft near take-off rotation. We subsequently found that the pylon separation was caused by major structural damage, which had resulted from maintenance abuse nearly two months earlier.

During the course of the safety investigation, the FAA issued a series of airworthiness directives requiring inspection of the DC-10 pylons. At one point, the DC-10 fleet was grounded for over a month while the FAA conducted a comprehensive investigation. Reinstatement of the DC-10 type certificate was accompanied by issuance of three airworthiness directives requiring strict adherence to a rigorous and repetitive inspection program for the wing pylon assembly.

In the case of the Sioux City accident, sir, the investigation continues by the National Transportation Safety Board, with FAA involvement, of course. And the probable cause has not been established by the board. We have not yet found the disk pieces that we need very badly in order to confirm the actual cause.

Preliminary data calls attention to both engine and hydraulics issues, in particular, concerns exist with regard to the vulnerability of the hydraulics system and about catastrophic engine failure. I have instituted action in both of these areas to address these concerns.

One of the lessons learned from what we know thus far of the Sioux City accident is that further means must be more fully explored to determine if there are ways, using today's new technologies, to better protect aircraft against this rarely experienced catastrophic engine failure involving the fan disk system or involving other types of external damage.

And we are doing that in two initiatives currently under way. One McDonnell-Douglas team is concentrating its efforts on a study to generate design changes, which would allow continued safe flight and landing in the event of failures of the number two engine, similar to the Sioux City accident, with the resulting damage to the hydraulic systems.

A second team is evaluating all systems vulnerability resulting from a multi-fragment high-energy failure of any engine or auxiliary power unit and/or the explosion of a landing gear tire in the wheel well.

Both teams are meeting weekly and FAA is a full participant in these issues. McDonnell-Douglas, as you know, announced last week a design fix to accomplish better survivability of the hydraulic system, and we fully support this design certification and will require it by making it mandatory through the issuance of an airworthiness directive in the near future.

I have also asked for a broader look at the issue of redundant systems for power-operated flight controls for all large aircraft. The Sioux City accident and the 1987 Japan Airlines Boeing 747 accident suggest to me the need for more stringent regulations governing the reserve capability of large aircraft with powered controls under emergency conditions.

An industry/FAA task force will examine this issue under the auspices of our recently established research and development advisory committee. This is a complicated issue, sir, which will take some time for the task force to deal with, but I am expecting to have available their initial findings after several months of effort on their part.

Unrelated to the Sioux City tragedy, we and the industry have been actively examining the DC-10 as one part of our overall aging aircraft program, since the international conference on aging aircraft in June of last year. This has led us to propose a number of structural changes to the DC-10, along with modifications or additions to current inspections designed to ensure continued structural integrity.

The DC-10, of course, is only one of the many aircraft types that we are addressing in our aging aircraft program.

Mr. Chairman, I would like to digress just a moment to let you know of our latest steps in the FAA to add to the safety of the DC-10 aircraft. Though we have not found the missing fan disk, as I mentioned before, our engineers have indicated that one possible scenario, which might have led to the uncontained engine failure were rotor disk bursts, is the development of a crack in the fan

disk as the result of an internal flaw in the disk material of titanium itself.

Since the accident, we have been working literally around the clock with the manufacturers and suppliers to understand how such a flaw might arise and develop. While we do not have all the answers yet, we have been able to isolate one particular material process in which the likelihood of such a flaw development is the highest.

We have been able to design and field-test an inspection process, which should give us assurance that there are no such flaws in engines in use today. Final field proof tests of the procedures were concluded this past weekend, and I ordered yesterday that these tests be applied to all General Electric CF6-6 engines of the type that were in the DC-10 in the Sioux City accident, of a certain material specification—those which use the so-called double vacuum melt process during the formation of the titanium material from which the rotor disks are then forged.

Briefly, the test we have required use state of the art ultrasonic technology and will be required in two stages: off the wing in a test called immersion ultrasonic inspection—the part is actually immersed in water—and for engines which cannot be immediately tested off the wing, to test them on the wing using contact ultrasonic inspections.

We have prioritized the inspection process into three lots and require inspection of the first two lots, a total of 55 engines, by November 21st of this year.

The remaining 165 engines will be inspected over the following two months so as to complete the inspection of all 220 double vacuum-formed disks by February 1990. These inspections will add further assurance that the Sioux City tragedy will never happen again.

In summary, Mr. Chairman, the FAA has worked closely with McDonnell Douglas and DC-10 operatives over the years to make refinements and improvements to the DC-10 to ensure that the traveling public receives safe transportation.

I am confident that these efforts have given us safe and reliable aircraft, and that on-going efforts to examine engine and control system issues will not only improve our understanding of these complicated issues, but will enable us to enhance safety requirements for all wide-bodied aircraft.

In closing, Mr. Chairman, I would like to acknowledge my appreciation of the Subcommittee's commitment to aviation safety and support of the FAA. We look forward to working closely with you as we work to improve the safety of our air transportation system.

This completes my prepared statement, Mr. Chairman, and I stand ready to respond to any questions you may have.

[The statement follows:]

STATEMENT OF THE HONORABLE JAMES B. BUSEY, FEDERAL AVIATION ADMINISTRATOR, BEFORE THE SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION, SUBCOMMITTEE ON AVIATION, CONCERNING THE DC-10. SEPTEMBER 19, 1989.

Mr. Chairman and Members of the Subcommittee:

I welcome the opportunity to appear before the Subcommittee to discuss with you actions the FAA has taken previously to respond to problems which have arisen with the DC-10, as well as steps we are taking to address concerns arising out of the recent Sioux City accident. At the outset, though, I believe it is important that I assure the public that the FAA considers the DC-10 to be a safe aircraft. I would stress that we have no safety information which would cause us to consider grounding the aircraft, as some have asked.

The DC-10 has been operating since 1971. During that time, the DC-10 fleet, of which 446 were built, has logged over 5 million landings and more than 15.6 million flight hours. Eight versions of the DC-10 have been approved by FAA, but one model (the DC-10-40F) was never built. Today, approximately 428 DC-10's/KC-10's, the military version, remain in service worldwide.

Of the seventeen DC-10 aircraft which have been destroyed in accidents prior to the Sioux City accident, only one accident--the crash of a Turkish Airlines DC-10 near Paris in 1974--appeared to

the FAA to involve a design deficiency that clearly played a significant part in the loss of the airplane. The Turkish Airlines tragedy involved the loss of a cargo door and subsequent loss of aircraft controls. Of the remaining accidents, three airplanes were destroyed on the ground undergoing maintenance or servicing; four airplanes were destroyed as the result of aborted takeoffs due to tire failure, bird ingestion in an engine, and taking off on the wrong runway into another airplane; seven airplanes were destroyed during landing where significant factors were pilot error and weather; one airplane was flown into a mountain; and another crashed on takeoff due to a maintenance-induced engine pylon failure.

The 1974 Turkish Airlines accident near Paris involved a cargo door latching failure. The separation of the cargo door from the aircraft resulted in depressurization which collapsed the aircraft floor impacting control cables which ran under the floor. Following the Turkish Airlines accident, the FAA issued an airworthiness directive (AD) to resolve the cargo door latching problem. The FAA also issued another AD for all wide body aircraft (DC-10, Lockheed L-1011, and Boeing 747) to improve the capability of the passenger and crew compartment floors to withstand, without collapse, an in-flight depressurization caused by the sudden opening of a large hole in the lower deck cargo compartment. Later, the Federal Aviation Regulations were amended

to incorporate new design requirements to correct this potential problem.

A number of other corrective actions were also taken after a DC-10 crashed on takeoff at O'Hare Airport in 1979. The accident was precipitated by the separation of the left engine and pylon from the aircraft near takeoff rotation. The structural and systems damage to the aircraft resulted in retraction of the left wing outboard slats, loss of stall warning, and loss of slat "disagreement" annunciation, which allowed an asymmetrical stall and uncontrolled, leftward roll of the aircraft. We subsequently found that the pylon separation was caused by major structural damage which had resulted from maintenance abuse nearly two months earlier.

During the course of the safety investigation, the FAA issued a series of AD's requiring inspection of the DC-10 pylons. At one point, the DC-10 fleet was grounded for over a month while the FAA conducted a comprehensive investigation. Reinstatement of the DC-10 type certificate was accompanied by issuance of three airworthiness directives. Briefly, the airworthiness directives required: strict adherence to a rigorous, repetitive inspection program for the DC-10 wing pylon assembly; inspection, periodic reinspection, and replacement of certain cables in the DC-10 slat

system; and proper operation, before any revenue DC-10 flights, of certain stall or takeoff warning systems.

In the case of the Sioux City accident, the investigation continues by the National Transportation Safety Board with FAA involvement so the probable cause has not been established by the Board. Preliminary data calls attention to both engine and hydraulics issues, in particular concerns exist with regard to the vulnerability of the hydraulics system and about catastrophic engine failure. We have instituted action in both of these areas to address these concerns.

With regard to the DC-10 hydraulic systems which provide control over the aircraft, much work has been done in the past to protect the hydraulics from catastrophic failures. For example, the DC-10 has triple redundant hydraulic systems in the aft section. Each control surface is operated by two different systems. The hydraulic lines of those systems are separated as far as possible and run along structural members in the aft fuselage and empennage. Each hydraulic system is powered by a separate engine, with two engine-driven pumps providing hydraulic pressure. Two electrically powered auxiliary pumps and two reversible motor pumps provide backup pressure for the various systems.

Priority was given to mutual spatial separation of the three systems. Where redundant power sources for a function required that one system be routed near another, the third system was kept as far away as possible from that area. Where geometric confines of the airplane restricted such separation, examination of high-energy parts trajectories guided the installation and location of equipment.

Prior to the Paris DC-10 accident in 1974, Douglas undertook a complete review of the DC-10 hydraulic system. Several changes to the hydraulic system were made, and FAA issued an AD to prevent hydraulic fluid loss in the rudder standby power hydraulic system from inducing an additional failure in an adjacent second hydraulic system, thereby maintaining flight control system capability. Additionally, approximately 18-20 design improvements in the DC- 10 hydraulic system were made by the manufacturer. Subsequent to the Paris DC-10 accident, the DC-10 hydraulic-powered flight controls were evaluated to assure they were adequately separated in light of new FAA requirements.

With the advent of the jets, significant changes occurred in engine technology. And as turbine engines evolved, thrust capabilities increased and the forces generated on engine components grew exponentially to provide that increased thrust. FAA's certification processes and the manufacturers' engine

testing processes are both exhaustive and demanding necessitating thousands of hours of testing, and, to the extent feasible, are designed to ensure that, if engine components fail, they will do so in a way that will not affect the safety of the aircraft. As engine rotor disks become larger and kinetic energy forces increase, it becomes increasingly difficult to ensure the containment of a failed rotor disk. Consider, for example, the General Electric CF6-6 first stage fan system weighs 750 pounds and generates kinetic energy of approximately 10 million foot pounds. The rotor disk alone weighs more than 270 pounds. Therefore, the FAA has sought to minimize rotor failure effects, using design techniques of redundancy, separation and isolation, and damage tolerance to contain and minimize damage from rotor shrapnel. One of the lessons learned, from what we know thus far of the Sioux City accident, is that further means must be more fully explored to determine if there are ways using today's new technologies to better protect airplanes against this newly experienced type of engine failure or other types of external damage. And we are doing that in two initiatives currently underway.

One McDonnell Douglas team is concentrating its effort on a study to generate design changes which would allow continued safe flight and landing in the event of failures of the Number 2 engine similar to the Sioux City accident with the resulting damage to

the hydraulic systems. A second team is evaluating all systems vulnerability resulting from a multi-fragment, high energy failure of any engine or auxiliary power unit (APU) and/or the explosion of a landing gear tire in the wheel well. The team is also looking at these issues in the context of the MD-11 type design. Both teams are meeting weekly with FAA on these matters. I should add that McDonnell Douglas is actively assessing possible design changes to meet the teams' objectives.

I have also asked for a broader look at the issue of redundant systems for power operated flight controls for large aircraft. The Sioux City accident and the 1987 Japan Air Lines B-747 accident suggest to me the need for more stringent regulations governing the reserve capability of large aircraft with powered controls under emergency conditions. An industry-FAA task force will examine this issue under the auspices of our recently established R&D advisory committee. This is a complicated issue, which may take up to one year for the task force to deal with, but I will be expecting to have available initial findings after several months of effort on their part.

Unrelated to the Sioux City tragedy, we and industry have been actively examining the DC-10, as one part of our overall aging aircraft program, since the International Conference on Aging Aircraft in June 1988. This has led us to propose a number of

structural changes to the DC-10, along with modifications or additions to current inspections designed to ensure continued structural integrity. The DC-10 is, of course, only one of many aircraft types that we are addressing in our aging aircraft program. We also expect to have developed a corrosion inspection program for the DC-10 by this October, and to initiate rulemaking to require the institution of such a program by DC-10 operators.

Mr. Chairman, I would like to disgress a moment to let you know of our latest concrete steps to insure safety of this airplane. Though we have not, as I indicated previously, found the missing fan disk, our engineers indicate that one possible scenario which might have led to the engine explosion is the development of a crack in the fan disk as the result of an internal flaw in the disk material itself. Since the accident, we have been working almost literally around the clock with the manufacturers and suppliers to understand how such a flaw might arise and develop. While we do not have all the answers yet, we have been able to isolate one particular material process in which the likelihood of such flaw development is highest. We have been able to design and field test an inspection process which should give us assurance that there are no such flaws in engines in use. Final field proof tests of the procedures were concluded this weekend, and I have ordered today that these tests be applied to all CF6-6 engines of

a certain material specification--those which used the so-called "double vacuum" melt process.

Briefly, the tests we have required use ultrasonic technology, and will be required in two stages: off the wing, in a test called "immersion ultrasonic inspection," and--for engines which cannot immediately be tested off the wing--on the wing, using "contact ultrasonic" inspections. We have prioritized the inspection process into three lots, and require inspection of the first two lots--a total of 55 engines--by November 21; the remaining 165 engines will be inspected over the following 2 months, so as to complete inspection of all 220 double vacuum fan disks by February 4. These inspections will add further assurance that the Sioux City tragedy will never happen again.

In short, the FAA has worked closely with McDonnell Douglas and DC-10 operators over the years to make refinements and improvements to the DC-10 to ensure that the travelling public receives safe transportation. I am confident that these efforts have given us safe and reliable aircraft, and that on-going efforts to examine engine and control system issues will not only improve our understanding of these complicated issues but will enable us to enhance safety requirements for wide body aircraft generally.

In closing, Mr. Chairman, I would like to acknowledge my appreciation of the Subcommittee's commitment to aviation safety and support of the FAA. We look forward to working closely with you as we work to improve the safety of our air transportation system.

That completes my prepared statement, Mr. Chairman. I would be pleased to respond to questions you may have at this time.

Senator FORD. Thank you very much, Admiral. I was pleased to hear you say that you are ordering inspection of the CF6-6 engines. As I understand it, there are about 220 of those.

Mr. BUSEY. Yes, sir.

Senator FORD. Are all of these engines on DC-10s?

Mr. BUSEY. Yes, sir.

Senator FORD. They are all on DC-10s. Have you made a judgment yet which engines to inspect first? How did you make a judgment on the 65, I think you said?

Mr. BUSEY. Yes, Mr. Chairman. What we did—and I might share with you that my colleagues and I spent a long time at the General Electric Plant at Avondale, thoroughly understanding the engine, reviewing the results of the accident investigation, the marks on the destroyed engine, reviewed the manufacturing process.

As I mentioned, we have narrowed down the engines of immediate interest to those formed by the so-called double vacuum melt process, wherein the basic titanium sponge material is formed through a melting process at very high temperature into billets, which are then hammered and forged into the final material from which the disks are cut.

We went back to the melting process, identified engine disks that were made from this initial process and from the process which included the disks and the failed engine. We have already investigated and inspected these engines. We have found in one disk a very tiny microscopic imperfection which has led us then to the process of back-tracking, identifying all other engine disks that were made in the same process, and thereby prioritize the inspection that we want to conduct.

So the first engines to be inspected were the ones that melted, initially, in this process, and that are the most suspect for having possible infinitesimal imperfections in the material.

Senator FORD. You have not limited the flights on those?

Mr. BUSEY. No, sir, we have not, because the one imperfection that we have found thus far has not progressed and it gives no indication of a cracking or impending failure.

We have devised a prudent inspection process that will require the removal of the disks that are most suspect and then we will do the inspections on the wing, if you will—men actually climbing into the engine on the wings and in the tail of the DC-10 aircraft and performing this ultrasonic inspection on the wing.

Of course, if there are indications of imperfections, those disks will be removed immediately and we have limited the flying hours of the disks that will continue in service so as to enable us to complete all of these inspections using the water tank immersion within a relatively short period of time.

Senator FORD. Admiral, on Friday, McDonnell Douglas announced that all DC-10s will be equipped with a shutoff valve in the tail to prevent loss of hydraulic fluid. It is my understanding that other wide bodies already have this feature. Why was it not required for the DC-10?

Mr. BUSEY. Mr. Chairman, the DC-10 hydraulic system is a triply-redundant system.

I have personally gone back through all of the drawings and the designs which indicate ample safety margins were created through the routing of these hydraulic lines to separate them and distance the three lines.

Most modern aircraft have at least triply-redundant systems. Some aircraft have what they call a quadruply redundant system, wherein there may be some other means of powering one of the hydraulic systems. So the original design of the DC-10 clearly provides ample separation and protection of all the hydraulic lines.

All other wide-bodied aircraft do not have a similar valving system. The 747, for example, the valving that we are talking about, similar what is being added into the DC-10, was added to the 747 after the Japan Airline incident, wherein the rear pressure bulkhead failed.

We have felt that the DC-10 was amply protected, and the addition of these new valves into the one system will provide an additional margin of safety to protect against another catastrophic accident such as we have seen.

Senator McCain and I saw a lot of aircraft that were combat-damaged by antiaircraft fire and missile fire in our careers, and when I observed the damage to this DC-10 aircraft at Sioux City immediately after the accident, I was amazed to see that the damage done to the tail section of the aircraft by this sudden burst and explosion of the rotor disk was far more significant and serious than any battle damage that I had seen done by antiaircraft fire. There was just no way that the three lines which must come together in the tail could have been protected against the tremendous forces that tore through that empennage section.

Senator FORD. When you say, "must come together in the tail of the aircraft," is that because of the design?

Mr. BUSEY. All aircraft have to have the hydraulic power lines moving into the empennage section of the aircraft to drive the elevators and the rudder systems, and most aircraft have different systems which drive different parts of the control systems in the tail, so of necessity these hydraulic lines and actuating cylinders must be in the tail section.

Now, when we consider the tail section of the DC-10, the expanse of the horizontal stabilizer, the elevator if you will, is about 73 feet, which is more than the wing span of the old DC-3 aircraft, and so we have a large area to separate hydraulic systems, and they were done—systems were separated by many feet in the tail section of that DC-10, but the tremendous shrapnel damage caused

by this first-time experience, catastrophic engine failure, just overwhelmed the system and led to the failure.

Therefore, these valves that McDonnell Douglas has proposed as a design change last week, which is a result of the team work that we have been participating in since July, is a good fix and adds more assurance to the preservation of hydraulic fluid and therefore the controllability of the aircraft such a tragic and catastrophic accident occur in the future.

Senator FORD. What is the procedure now, Admiral, that McDonnell Douglas has proposed for these new valves, and do you have to mandate it? Is it an automatic? If you do mandate it, will you specify a compliance period?

Mr. BUSEY. Yes, sir. We will, in fact, do that, and we are still gathering the information.

Senator FORD. You are going to do what, now? You are going to mandate it?

Mr. BUSEY. We will mandate it. We are in the process of mandating it through an airworthiness directive requiring the installation of this change in all DC-10 operations, all aircraft, and we will indeed specify a time limit, and of course my objective is as short a time period as possible, but I am gathering data right now to find out how fast can the manufacturing process be culminated so that these hydraulic valves, which are rather complex, how soon can they be available to us?

But once we get that data and the kits can be formed, we will immediately start the installation on all users. The users of this aircraft here in this country and some foreign operators have already indicated their eagerness and their willingness and readiness to have these systems installed, and so we are moving just as fast as we can.

Senator FORD. You responded to my question a few moments ago that other wide bodies already had this feature of the shut-off valve, and you said that was not necessarily so, I guess, when they were manufactured, but they have been required after accidents.

Well, you cited several major tragic accidents of DC-10s, and yet it has not been mandated or required for the DC-10. I just wondered why you mandate it for other wide-bodied aircraft after accidents, and for the DC-10 after their accidents, it was not mandated?

Mr. BUSEY. The requirement for the 747, as I recall Mr. Chairman—I will ask Mr. Broderick to back me up on this, but the failure of the pressure bulkhead in the 747 was such that all the hydraulic lines going to the empennage section passed through a relatively small area—a hole, if you will, in that pressure bulkhead—and of course, when it failed, which was unforeseen, and it failed because of the lack of proper maintenance, all of the redundant hydraulic systems were made inactive. It was following that that the change, as I recall, was mandated for the 747, and of course Boeing then saw fit to install a similar system in their 757 and 767 aircraft.

We did not see a need for that in the DC-10 at that time, because of the wide separation of the hydraulic systems in their design and manufacturing process, and of course none of us at those times

foresaw a catastrophic failure, a rotor burst failure, such as we experienced on the United 232 flight in July at Sioux City.

Senator FORD. My final question is—and I do not want to delay my colleagues, but most of the modifications that you mentioned have been made after an accident demonstrated a need.

This kind of goes to the heart of what I am thinking about here this morning. Should the FAA require more testing before a design is approved? Would more stringent compliance with standards, more life cycle testing, help to identify these problems before there is a tragedy?

Mr. BUSEY. Yes, Mr. Chairman, and I constantly ask myself the same question and the answer that I can provide now, after my short time at the FAA, is that the certification process, the testing process which precedes the granting of a final certification as safe to operate in revenue traffic for any new aircraft is very extensive and very expensive.

We are constantly evolving the certification requirements, the rules that we require producers of new aircraft to adhere to and to demonstrate to us, so it is a constantly moving process.

In aviation, in my experience in aviation we have always learned from accidents. None of us can foresee and forecast all of the incidents that we must protect and design against up front, so our tradition and the history of aviation in my judgment is rich with after-the-fact lessons learned, and that is why we do such in-depth investigations and try to get to the exact causal factors so we can ask ourselves, have we done everything possible to ensure that this does not happen again, and if not, then let us move on and go with those fixes.

That is why we are going with this inspection process on the rotor disks.

Senator FORD. Well, admiral, are you sensitive to the comments that your European counterparts require more stringent compliance with regulations than the FAA?

Mr. BUSEY. I am sensitive to those comments. We are constantly working with those foreign manufacturers, and from what I have learned thus far, in the majority of areas requiring certification I think we are, perhaps, more stringent in our requirements than our foreign allies. However, what we are moving towards in the years ahead is a more standardized approach to that process.

Senator FORD. Thank you very much, Admiral.

Senator McCain.

Senator MCCAIN. Thank you, Mr. Chairman. Thank you for your testimony, Admiral.

One of the major criticisms concerning the DC-10, as I understand it, is based on the fact that the engine is placed in the tail to start with?

Mr. BUSEY. Right.

Senator MCCAIN. So let us, can we, walk through this accident just in layman's terms, very briefly?

It was a catastrophic failure of the engine which basically shredded all of the hydraulic lines. And, therefore, with no backup hydraulic power, the airplane was, to a large degree, uncontrollable. Is that an accurate depiction?

Mr. BUSEY. Yes, sir.

Senator McCAIN. If the engine on the wing had experienced the same catastrophic failure, would there have been the same effect on the hydraulic lines, and, therefore, the same effect on the pilot's ability to control the aircraft?

Mr. BUSEY. That is very difficult to say, Senator. There would have certainly been a lot of damage, judging by what I saw on the empennage of United Flight 232. There would have certainly been damage in the wing, hydraulic lines, due serve leading edge slats, flaps, and ailerons in the wing.

There would, undoubtedly, have been severe damage to those hydraulic systems even though they are widely separated because of the tremendous forces involved with this kind of a failure.

There probably would have been controllability problems, but I am not expert enough to tell you exactly whether they would have been the same kind of controllability problems or not.

Senator McCAIN. In order for the hydraulic lines to get to the tail, they have to come in proximity to each other at some point, is that correct?

Mr. BUSEY. Yes, sir.

Senator McCAIN. Would those same hydraulic lines have to be in that same proximity when they go out to the wing, to the engines on the wings?

Mr. BUSEY. Yes, sir. From my recollection of the design drawings and the routing of hydraulic systems in the wing, the same efforts were made to separate them by many feet and to protect them by routing them through spar assemblies, which are heavier, more heavy metal assemblies in the wing and the tail area.

I respectfully submit, sir, that our McDonnell Douglas representative, who will follow me later this morning, will certainly be more expert to give you a detailed answer to that question.

But the same procedures to separate the routing of hydraulic lines in the wing applies as it does in the tail section.

Senator McCAIN. The nature of this accident has not led you to question, or if it has led you to question, it has not led you to the conclusion that a basic design feature of a large, wide-bodied airliner is less safe if you have engines in the tail as opposed to being out on the wing?

Mr. BUSEY. No, sir. Not at all, not at all.

Senator McCAIN. Absolutely not?

Mr. BUSEY. Absolutely not.

Senator McCAIN. You mentioned in your statement the need for more stringent regulations governing the reserve capability of large aircraft with power controls under emergency conditions. Is there any way to avoid a total reliance on hydraulic power for flight control systems?

Mr. BUSEY. Not on these large aircraft, sir. The forces, the air dynamic forces that are acting on the tail section and on the wings are of such magnitude that, for example, an electric drive would require a motor of such horsepower that it would preclude its use because of the size and weight, the volume and weight requirements.

The hydraulic systems that have evolved, the 3,000 pound hydraulic systems, are used in all present large aircraft and military aircraft installations. And that is where we are in the state of tech-

nology at this time, to be able to transmit the forces necessary to move those control, those large control surfaces because of the forces acting on them.

Senator McCain. Without getting too technical, is there a way of installing a mechanism that would freeze those flight controls in an optimum position?

Mr. Busey. Yes. There is technology available to us, and such a capability may exist on the DC-10.

Mr. Broderick. The DC-10, one of the advantages of the DC-10 is that the trim system is activated by jackscrews which, in fact, stay in place. That is why this airplane was, in fact, controllable through the use of power.

An airplane which uses full hydraulic systems without a screw-jack like that, will not be controllable in the event of a total loss of power.

So that kind of thing is available on the DC-10.

Senator McCain. I am very interested in hearing more about and getting results of your studies and task force on aging aircraft.

Finally, do you have any indication that this accident was in any way related to the age of parts of the engine, or the aircraft?

Mr. Busey. No, sir. We have absolutely no indication to that, of that at all. In fact, the air frame and the engine itself, the maintenance records, look good thus far through the investigation; only half of the predicted life, approximately, had been achieved or consumed by the aircraft and by the engine itself.

So we have no indication that the aging of this aircraft is a factor.

Senator McCain. How old was the aircraft?

Mr. Busey. I believe it is about 15 years old.

Senator McCain. And the life is about 30 years, roughly?

Mr. Busey. Approximately. Of course, the life of aircraft is measured in cycles, the pressurization cycles, and I believe this aircraft had accumulated about half of that, I believe 30,000, approximately.

Mr. Broderick. It was fewer than that in cycles, but we can get the data for you exactly. But it was a middle-aged airplane, certainly not an aging airplane.

Senator McCain. Thank you, and thank you Mr. Chairman.

Senator Ford. Thank you, Senator McCain.

We are pleased to have the distinguished Senator from Alaska, Senator Stevens.

Senator Stevens. Thank you, Mr. Chairman.

As I understand this United incident, the conclusion seems to be that the basic problem was from the engine, and not from any portion of the air frame, is that right?

Mr. Busey. Yes, sir. That is our preliminary assumption.

The NTSB is still investigating the accident; they have not come up with the final cause of the accident, sir.

But the expert judging of the signature left behind by the mode of failure of the engine, leads us to several scenarios. And the most likely one at this time is the failure of the fan, the number one fan disk itself, which, for some reason, came apart, fractured, and because of its weight, the mass, the rotational velocity of this fan generated tremendous energy, in the neighborhood of several millions

of foot pounds, which then fragmented and created the damage, the impact damage with fragments on the tail of the aircraft.

Senator STEVENS. I always thought there was some sort of a sensor on these jet engines that would measure vibrations. Are those still there?

Mr. BUSEY. Yes, sir. There are vibration sensors, and to the best of my recollection, such sensors are available on the DC–10.

Mr. BRODERICK. They are available; I do not think we need them. But I would point out that this entire incident occurred within about one quarter of a revolution, which is about four one-thousandths of a second from beginning of the fracture until the end of the explosion, so there was no time to react.

Senator STEVENS. It was not something that came from vibration, and not because it came from a seizure of the blade—it was a disintegration of the blade?

Mr. BUSEY. Disintegration, sir, of the disk, the solid titanium disk that weighs about 270 pounds, to which the blades are attached on that forward-fan assembly.

No vibration indicator would have given an impending warning of this. The vibration sensors tend to give the pilot, the cockpit crew, an indication of bearing failures, oil failures, something internal to the engine, which give them a warning in advance so that they can consider shutting down the engine, for example.

Senator STEVENS. Well, there was one indication, as I understand it, in the reexamination of similar disks, that showed a flaw, is that correct?

Mr. BUSEY. Yes, sir.

Senator STEVENS. Now, was that discovered by x-ray?

Mr. BUSEY. No, sir. That was discovered by ultrasonic inspection and immersion in a water bath with the computer control, very carefully conducted sonic examination.

Senator STEVENS. Are the parts of similar engines that are in use now, being subjected to a similar inspection?

Mr. BUSEY. Yes, sir. I directed yesterday, through a rule-making process, an airworthiness directive, such an inspection with very tight time frames and a prioritization of the disks that we want to see inspected.

We have already inspected something approaching 25 disks that have now been inspected in detail.

Senator STEVENS. Was there some indication that this was a composite, a molded portion of this engine?

Mr. BUSEY. Sir, we are operating on the hypothesis that the impurity that we found through this ultrasonic inspection was left in the titanium material during the initial melting process. A double vacuum melt was conducted at this time, about 15, 16 years ago. That was the state of the technology at that time.

And, somehow, this tiny imperfection, this impurity, was introduced through the melting process. The melt process has subsequently changed.

But what we are after is an inspection, a detailed inspection of all the titanium disks that were formed through this so-called double vacuum melt process which was a state-of-the-art several, many years ago.

Senator STEVENS. Was that a process that was exclusive to the one-engine manufacturer?

Mr. BUSEY. No, sir. It was not exclusive to the one-engine manufacturer and we are continuing to investigate that. Each manufacturer specifies a certain alloy, and a certain process, so we are concentrating our efforts for now on the specifications that G.E. levied on the producers of this material at that time, so that we get at the disks that were forged and installed on the CF6-6 engine.

We are continuing our look and our investigation into Pratt & Whitney engines, and into Rolls Royce engines which also make large, high-bypass engines.

Senator STEVENS. One last question. Is this engine used by our Department of Defense?

Mr. BUSEY. A derivative, a model of this engine, is used on the U.S. Air Force 747-type aircraft, I believe. It is used on KC-10 and on Air Force One—a derivative of the engine, not the CF6-6 engine, which is the instant engine of our concern. Those engines, those later engines, are other derivatives.

Senator STEVENS. Are they subject to a similar inspection now?

Mr. BUSEY. As we gain experience in inspecting these first engines, of those exclusively produced by the so-called, double-vacuum melt process, as we gain experience, we will know more as to whether we should go on and inspect the other disks. We do not have enough information to proceed that way yet, sir.

Senator STEVENS. Thank you very much, Mr. Chairman.

Senator FORD. Thank you, Senator Stevens.

We're pleased to have the ranking member, Senator Danforth, with us this morning. Senator Danforth.

Senator DANFORTH. Mr. Chairman, thank you very much.

Admiral, any time there is a disaster, an air disaster, the flying public immediately asks, well, is this going to happen to me.

As a matter of fact, yesterday, I talked to somebody who had just taken a DC-10 from California to Washington, and exactly the same concern was expressed.

Is there any reason for the public to be especially concerned about the DC-10?

Mr. BUSEY. Absolutely not, Senator Danforth. I, again, give my assurance, the DC-10 is a safe airplane, it is safe to fly. We have absolutely no reason to suspect otherwise, and no reason to consider the grounding of this aircraft.

Senator DANFORTH. The engine problem, the disk problem which you suspect was the cause, could that equally have happened in other types of aircraft?

Mr. BUSEY. Yes, sir. That possibility and probability is there. This is the first failure, catastrophic failure of this type that we have experienced in my knowledge in many, many years of operation.

All of these large, high bypass, high ratio bypass, very powerful engines, are constructed similarly. The specific technologies are different in each aircraft, but we protect against this type of failure as best we can through the qualification and certification process, and we are considering all engines in our investigation, not just the General Electric CF6-6 engine.

Senator DANFORTH. Thank you, Mr. Chairman.

Senator FORD. Thank you, Senator Danforth.

Senator Exon.

Senator EXON. Mr. Chairman, thank you very much. I congratulate you on calling this hearing. I think it is a very important matter. Let me ask a general question.

Do you or your agency have any overall statistics on whether or not there has been a significant increase in the difficulty with airlines in general, or our commercial fleet as opposed to last year and the year before that?

We had some tragedies of major proportion and I am glad to see you are moving on those. We have to always keep this in proper perspective, and I honestly do not know whether we have had more tragedies or incidents in the last year than we did in the years previous to that.

Could you enlighten the committee with any information you have along those lines?

Mr. BUSEY. Yes, Senator Exon, we do have some statistics through my safety office; the National Transportation Safety Board also has statistics. And I can share with you that the statistical information that I have recently reviewed clearly indicates that the accident and incident trend in commercial aviation has significantly decreased since the introduction of the so-called wide-body aircraft.

Senator EXON. Has significantly what?

Mr. BUSEY. Decreased.

These aircraft are safe. The technology is enabling us to achieve new highs in safety performance at the same time that we have significantly increased the number of commercial aircraft operating in our country since deregulation in 1978. I think it is very meaningful.

And I might also add that the statistics that I have reviewed clearly indicate that the DC-10 is no worse, from a statistical performance standpoint, than any other aircraft.

Senator EXON. What assurances can you give the committee with regard to our "aging" commercial fleet of aircraft? I guess they are aging from the standpoint that we are using them longer than we used to. How much of a concern is this to you as the director?

And second, what information, specifically, do you have to make certain that with deregulation and the pressure that deregulation has placed upon the competitive marketplace to keep aircraft flying—I mean, the commercial operators fly these airplanes, I think, and work them harder than they have ever been worked in the past. That is a supposition on my part, but I believe it is a fairly accurate supposition. The other side of that, of course, is how well are the regulators enforcing the maintenance inspections on these aircraft?

You have levied some fines recently, and I am glad to see that and I applaud that effort. What is your overall view of these matters? And if you have some shortcomings, what plans do you have to correct them, as the new director?

Mr. BUSEY. Yes, sir, Senator Exon. I am confident that we in the FAA have oversight compliance regulatory processes in place to ensure that these maturing aircraft are properly maintained.

We have several task forces/study teams that have looked at the Boeing aircraft, first, that led us to airworthiness directives and enforcement action, that required certain changes and procedures and changing in the inspection process to be taken.

Recently the teams have completed their work on all McDonnell-Douglas series aircraft, including the DC-10, and that will lead to mandatory requirements to change the maintenance specifics.

We are looking at other manufacturers' aircraft. We will look at commuter aircraft. And we are even looking at general aviation aircraft to see what changes we need to consider making from a maintenance standpoint.

We are simply going to be flying these maturing aircraft longer. The new aircraft manufacturers are being totally taxed for their new production capacity; order books are filled. The demand continues to grow for commercial traffic transportation, so the facts of life clearly indicate to us that we will be flying these aircraft longer. And therefore we need to pay more attention to the proper maintenance procedures to ensure that we can safely operate them longer.

We are working in consort with the Department of Defense, all the military services who have experience in corrosion control, for example, that we perhaps do not have as in-depth knowledge of in the commercial world, to ensure that we are bringing in corrosion control procedures that will enable us to operate these aircraft confidently and safely.

So I believe today, as we speak, we have the mechanisms in place. I have the FAA maintenance oversight and compliance persons actively in place at the places where the contractors and the users, the major airline operators, are maintaining their aircraft to ensure that our procedures are being followed.

As we gain experience in this teamwork process that we are involved in between government and industry, we will apply new requirements, I am sure, to ensure the continued safe operation of these aircraft.

But, in my judgement, there is no reason why, if an aircraft is properly maintained, that it cannot be flown indefinitely.

Senator EXON. Overall, from your experience, before you assumed this new position, with what statistics that have come to your attention, do you believe that we could rationally say that airline safety overall is as good today as it was before deregulation?

Mr. BUSEY. Yes, sir, I very definitely feel we can say that overall airline safety is at least as good today as it was before deregulation, and, in fact, the trends indicate that it is probably better today than it was prior to deregulation.

Senator EXON. Give me your opinion with regard to the potential problems with the DC-10 and the MD-11, which I understand is the follow-on, very similar version of that aircraft; whether or not the basic design, as I understand it, as a person not expert in design at all of aircraft, but as I understand the tragedy in Sioux City was failure of an engine, which we can anticipate from time to time. But the basic design of that aircraft has some potential perils connected with it, because of the concentration of hydraulic lines in that part of the airplane, and if an engine fails, where the fins fly off, as they did in that position, where you just had an accident

waiting to happen, as opposed to aircraft that have the engines out on the wings.

When I talk about faulty design, I am not talking about faulty design from the standpoint of the performance of the aircraft or the efficiency of the aircraft, I am talking about is there a possibility that the DC–10 falls into the potential category of being a potential safety hazard because of the concentration of control lines near the engines, which do fail from time to time.

Is that a legitimate concern?

Mr. BUSEY. Senator Exon, in my judgement, I do not categorize the DC–10 design in a category of a poor design or a faulty design. I am satisfied that as we went through the certification process, which begins at the early design stages of that aircraft——

Senator EXON. But when you go into certification, do you look at the safety angles?

Mr. BUSEY. Yes, sir. And of course safety is the number one concern as we go through the design process. And I am satisfied that all prudent steps were taken in the design of the DC–10 to separate hydraulic lines, to shield them as best they could be shielded by the stronger structures of the tail. But there is simply no way to avoid, at some point, bringing hydraulic systems together.

Now, as far as the MD–11 is concerned, the same type of a safety oversight and review, from the design to the manufacturing process, is in place. The new technologies will be investigated and agreed to. Our safety standards will be employed. And the certification process is a constantly ongoing process.

As we modify the rules for certification in the FAA, over the years, and a new aircraft or a derivative aircraft is developed, we apply the newly-evolving rules and not those rules that existed some years ago. So as state-of-the-art, as new technology, new design techniques are introduced, composites, for example, safety concerns and demonstrated performance is a requirement of ours in the certification process.

Senator EXON. Admiral, thank you. My last question, Mr. Chairman, has to do with what struck in my mind when you indicated earlier in your testimony that you had been working with the Air Force to coordinate on all things.

Has the Air Force had any unsatisfactory or unexplained difficulty with the KC–110 like has been experienced in their cousins, the DC–10, over in the commercial sector? Has there been any indications of that at all from the service side?

Mr. BUSEY. No, sir, not to our knowledge. And I might add that the KC–10 has a commercial airworthiness certification exactly similar to that which is imposed on the commercial aircraft designed and built for revenue traffic.

Senator EXON. Thank you very much, Admiral.

Thank you, Mr. Chairman.

Senator FORD. Do any of my colleagues have any additional questions of the Admiral?

[No response.]

Senator FORD. Admiral, let me just say to you that I regret that we had to have this hearing under the circumstance, because of the accident, but I am glad to know we can have somebody here who can testify and understands an airplane inside and out, and can

start describing parts of an airplane that are significant and why. And it is pleasing to me to have somebody like Senator McCain here that understands, and you all can talk that language and we get it into the record, though.

And I do compliment you on your assistant that is with you this morning. We appreciate both of you coming and look forward to working with you.

Thank you for your testimony this morning.

Mr. BUSEY. Thank you, Mr. Chairman.

Senator FORD. The next witness will be the Hon. James L. Kolstad, acting Chairman, National Transportation Safety Board.

STATEMENT OF JAMES L. KOLSTAD, ACTING CHAIRMAN, NATIONAL TRANSPORTATION SAFETY BOARD, ACCOMPANIED BY BUD LAYNOR, DEPUTY DIRECTOR, BUREAU OF TECHNOLOGY

Mr. KOLSTAD. Good morning, Mr. Chairman, members of the Subcommittee.

Senator FORD. If you would recognize the gentleman accompanying you there, we would be delighted to hear your testimony this morning.

Mr. KOLSTAD. On my right is Mr. Bud Laynor, who is the Deputy Director of the Bureau of Technology at the Safety Board.

As Admiral Busey, I have a longer statement to submit for the record, Mr. Chairman, and I will summarize my statement.

Senator FORD. That will be fine, and your total statement will be included in the record and we appreciate you highlighting it.

Mr. KOLSTAD. Thank you. The Safety Board is pleased to participate in these hearings regarding the safety of the McDonnell Douglas DC–10.

The uncontained engine failure that led to the fatal accident of United Airlines Flight 232 in Sioux City, Iowa, on July 19 of this year, followed by a crash of a Korean Airlines DC–10 in Tripoli, Libya on July 27 and another uncontained engine failure on a Northwest DC–10 on August 9, has again raised the public's concern about the safety of this aircraft.

The dialogue from this hearing we believe should help to assure the public that the events that have raised their concerns are being fully investigated. I would like to point out, however, that the overall safety record of commercial aviation since the introduction of the second generation turbojet airplanes, including the early wide-bodied airplanes in the mid-1960s and early 1970s has been outstanding, far surpassing the safety records of previous airplanes.

The Sioux City accident is the second in this country involving a DC–10 in which there were more than two fatalities, the first accident being the crash of American Airlines Flight 191 in Chicago in 1979.

Other accidents involved an operationally-induced uncontained engine failure that resulted in a rapid decompression, an accident involving a blown tire during a rejected takeoff, and an icy runway overrun. These accidents accounted for three fatalities, and two other persons missing and presumed dead.

Furthermore, the Turkish Airline's cargo door accident of March 3, 1974, is the only one of the four fatal DC–10 accidents that have

occurred outside of the continental United States that has not been attributed to operational factors.

The significant point, though, is that the Safety Board's investigation of DC–10 accidents to date have uncovered no common thread that would suggest a fundamental design flaw of the airplane.

Some media reports have attempted to link the circumstances of the 1979 American Airlines crash to those of the United Airlines Sioux City accident by citing both of these as examples of hydraulic system deficiencies.

In point of fact, however, the breach of the number three hydraulic system was not a factor in the 1979 American accident at O'Hare. The uncommanded retraction of the leading edge slats was caused by a severed control cable.

The circumstances of the United Airlines Sioux City accident have, however, renewed industry-wide questions about flight control system redundancy on wide-bodied aircraft.

Our investigation of the United Sioux City accident has determined that most of the first stage fan rotor assembly separated from the number two engine in flight. The separation, fragmentation and forceful discharge of the fan rotor parts inflicted shrapnel damage to the empennage of the airplane, including severed hydraulic lines.

Of major importance is the need to identify the precise cause of the fan disk separation on the flight 232 General Electric CF6 engine. To date, the separated components have not been found although an intensive search effort of fields in the area where the separation occurred continues.

The Safety Board has conducted computerized trajectory analysis to establish the probable location of parts and has used infrared-equipped airplanes to pinpoint debris in corn fields and bean fields. Ground search teams have been into many of these areas without success. We are hopeful, though, that the parts will be found during the harvest of these fields in the very near future.

The evidence of parts that remained with the airplane, and other parts found in the fields, indicate the possibility that the failure was initiated in the first stage fan disk. Consequently, six other disks that were manufactured from the same material lot of the accident disk have been undergoing detailed immersion ultrasonic examinations as well as other nondestructive testing at the General Electric facility.

All but one of these disks and others that have been inspected since the accident have been free from metallurgical flaws. One of the disks did have a metallurgical anomaly, the significance of which is being thoroughly analyzed by other tests.

Although the failure of the fan disk may have resulted from a unique problem, the Safety Board has recommended that the FAA take action to assure the safety of the General Electric CF6–6 engine, and we are pleased to learn that they are responding.

As with all of the wide-bodied airplanes, the movements of the flight control surfaces that control the DC–10 airplane in pitch, roll, and yaw, are accomplished by hydraulic actuators because the control loads are too high for direct mechanical actuation by the pilot.

The certification basis for the airplanes require that after any single system failure sufficient redundancy exists to redistribute the functions of the failed system so that the airplane can be safely controlled.

The DC-10 complied with the certification requirements by dividing the power to the primary flight controls as well as the wing flaps, landing gear, wheel brakes and nose wheel steering among three independent hydraulic systems.

The design is such that, in the event of the loss of any one of the three hydraulic systems the airplane can be flown with little degradation of controllability. Even in the event of a loss of two of the three hydraulic systems, the remaining system will provide sufficient flight control to land the airplane safely.

Both the 747 and the Lockheed 1011 have four independent hydraulic systems, but these airplanes have also proven to be vulnerable to multiple system failures.

Although the airplane certification rules require hydraulic system redundancy, the rules do not provide for the protection of systems in the event of major airplane structural damage such as occurred on Flight 232.

Total protection of structure and systems under such circumstances has been considered by the industry to be impractical because of the high energy during failures of heavy rotating engine parts.

Further, the hydraulic and flight control systems of all airplanes are vulnerable when serious structural damage, such as that inflicted by an uncontained engine failure, occurs. This is particularly true when damage affects the empennage, where multiple systems are needed to operate elevator, rudder and horizonal stabilizer controls.

Clearly, a failure of high energy rotating parts is an intolerable event, and the engine components are supposed to be designed with a safety margin that makes such failures improbable during the allowable life of the parts. To date, the Safety Board has found no instance wherein specific components or design areas of the DC-10 do not comply with FAA certification requirements applicable at the time of manufacture.

That is not to say, however, that the certification process and the design of these airplanes cannot be improved. The lessons learned from accidents are often the impetus for such improvements, and we hope that will continue. We now understand McDonnell Douglas has developed a modification which is intended to preserve the integrity of the number three hydraulic system in the event of a catastrophic failure as has occurred on United Flight 232.

Another accident, fortunately nonfatal, involving a DC-10 airplane, has already led to a review of certain certification procedures and industry changes. In May of last year, an American Airlines DC-10 was declared a total loss after it overran the runway as a result of a rejected takeoff from the Dallas-Fort Worth Airport.

An examination of the airplane's brakes and the runway surface after the accident disclosed that eight of the ten brakes had failed during the early part of the attempted stop. The brakes could not withstand the heat introduced by the energy of a rejected takeoff.

New airplane braking performance is demonstrated during initial FAA certification only with all new brakes. In subsequent line operations, brake wear limits are set somewhat arbitrarily, and before this accident there apparently was no consideration given to the differences in heat transfer characteristics of brakes after they are worn.

Since this accident, there have been numerous tests using dynamometers to evaluate the performance of worn brakes. The results indicate that the airplane's stopping distance may be longer than suspected with worn brakes, even though the design and brake wear limits permit a full stop without failure.

This problem is likely not unique to the DC–10, thus we believe that a complete review is necessary of the brake performance and certification requirements for existing and new transport category airplanes, with attention to the establishment of performance standards for brakes that are worn but within acceptable service limits.

In summary, the Safety Board's accident investigations do not indicate that the DC–10's certification and operating history is uniquely different from that of other wide-bodied transport category airplanes. While in retrospect all of these airplanes may have benefited from some design improvements, their operating records have placed them among the safest airplanes in history.

That completes my statement, Mr. Chairman. I will be pleased to respond to your questions and those of your colleagues.

[The statement follows:]

STATEMENT OF JAMES L. LOLSTAD, ACTING CHAIRMAN, NATIONAL TRANSPORTATION SAFETY BOARD

Mr. Chairman, members of the subcommittee, the Safety Board is pleased to participate in this hearing regarding the safety of the McDonnell Douglas DC-10.

The uncontained engine failure that led to the fatal accident of United Air Lines flight 232 in Sioux City, Iowa on July 19, 1989, followed by a crash of a Korean Air Lines DC-10 in Tripoli, Libya on July 27, and another uncontained engine failure on a Northwest DC-10 on August 9, has again raised the public's concern about the safety of this type of aircraft. The dialogue from this hearing should help to assure the public that the events that have raised their concerns are being fully investigated.

I would like to point out, however, that the overall safety record of commercial aviation since the introduction of the second generation turbojet airplanes, including the early wide body airplanes in the mid 1960's and early 1970's, has been outstanding, far surpassing the safety records of previous airplanes.

There have been 370 DC-10 airplanes produced since its type certification in 1971. Fifteen airplanes have been destroyed or retired from service as a result of accidents and two were destroyed by fires that occurred during the performance of maintenance. There have been 15 events worldwide involving the

DC-10 in which one or more fatalities resulted. Four of these events involved persons who were injured while boarding, exiting, or working in the vicinity of an airplane on the ground. The other 11 events were attributed to a variety of causes.

The Sioux City accident is the second in this country involving a DC-10 airplane in which there were more than two fatalities, the first accident being the crash of American Airlines flight 191 in Chicago on May 25, 1979. Other accidents involved an operationally-induced uncontained engine failure that resulted in a rapid decompression, a blown tire during a rejected takeoff, and an icy runway overrun. These accidents accounted for three fatalities and two other persons missing and presumed dead. Furthermore, the Turkish Airlines cargo door accident of March 3, 1974 is the only one of the four fatal DC-10 accidents that have occurred outside of the continental United States that has not been attributed to operational factors.

The significant point, though, is that the Safety Board's investigations of DC-10 accidents to date have uncovered no common thread that would suggest a fundamental design flaw of the airplane.

It was the tragic loss of 346 lives in the Turkish Airlines accident in 1974 that first attracted public attention to the DC-10. In 1979 the crash of an American Airlines DC-10 at Chicago still stands as the worst crash in United States aviation.

You may recall that the Turkish Airlines DC-10 crashed shortly after takeoff from Paris, France, claiming 346 lives, the highest loss of life in any single aviation accident at the time. It was determined that the airplane's left rear cargo door had not been properly latched, although the locking mechanism appeared to have been secured before departure. The door opened and separated while the airplane was climbing through 12,000 feet, and the pressure differential above and below the cabin floor caused the floor to buckle, severing critical cables to the flight controls.

A tragic aspect of this accident was that the potential for a catastrophic accident resulting from an improperly closed cargo door had been identified nearly two years earlier when a cargo door separated from an American Airlines DC-10 near Windsor, Ontario. In that occurrence also, the sudden decompression of the cargo compartment caused the cabin floor to buckle, which damaged flight and engine control cables. Fortunately, the captain retained sufficient flight control to land the airplane in Detroit.

Two airplane modifications had been recommended by the Safety Board after the Windsor, Ontario accident -- a redesign of the cargo door locking and latching mechanism, and the installation of pressure relief vents between the upper cabin and

lower cargo compartments of the DC-10 to prevent buckling of the cabin floor during a rapid decompression. Unfortunately, corrective modifications had not been mandated by the FAA for the U.S. fleet and had not been incorporated on the Turkish DC-10.

An airworthiness directive subsequently was issued by the FAA and the DC-10 cargo door locking mechanism deficiencies were corrected.

A year later, in 1975, airworthiness directives were issued to require cabin floor vents on other wide bodied aircraft, as well as the DC-10, and later on all new transport category aircraft. We believe that these pressure equalization vents may have been a factor in preventing higher loss of life when a cargo compartment door separated from a United Airlines Boeing 747 after taking off from Honolulu on February 24, 1989.

In the American Airlines flight 191 accident, the left engine and pylon assembly and about three feet of the leading edge of the left wing separated from the airplane as it rotated for takeoff from Chicago. The airplane climbed about 300 feet, suddenly rolled to the left and pitched down into an open field. Two hundred and seventy one persons on board and two persons on the ground were killed.

The investigation determined that the engine pylon structure had been weakened by damage which had been inflicted during the airline's performance of an improper maintenance procedure. When the pylon and engine separated, the airplane's number three hydraulic system tubing and control cables leading to the left outboard leading edge slats were severed causing the slats to retract. The airplane had attained an airspeed after liftoff sufficient for continued flight with the leading edge slat asymmetry. The pilot, however, followed the pitch commands on his flight director for two-engine flight, slowing the airplane to an airspeed at which the left wing stalled.

It is ironic that, as with the cargo door problem, the potential for damaging the engine pylon structure during maintenance had been identified earlier by another airline but was given too little attention by the manufacturer. Further, the FAA's Service Difficulty Reporting System excluded the need to report maintenance-induced damage -- thus depriving the FAA of the opportunity to analyze a potentially serious problem. Following the American Airlines Chicago accident, maintenance practices and operational procedures were reviewed and changed.

Some media reports have attempted to link the circumstances of the 1979 American Airlines' crash to those of the United Airlines Sioux City accident by citing both as examples of hydraulic system design deficiencies. In point of fact, however,

the breach of the number three hydraulic system was not a factor in the 1979 accident; the uncommanded retraction of the leading edge slats was caused by a severed control cable.

Although analysis and tests showed that the DC-10 is controllable at normal takeoff airspeeds with the slats on one wing retracted, another event in 1981 prompted the manufacturer to modify the slat control valve so that the slats, if extended, will remain extended in the event of severed cables or hydraulic pressure loss.

The circumstances of the United Airlines' Sioux City accident have, however, renewed industry-wide questions about flight control system redundancy on wide-bodied aircraft.

United Airlines flight 232 was enroute from Denver to Chicago with 285 passengers on board, cruising at a flight level of 37.000 feet when the crew heard an explosive sound from the rear of the airplane and noticed abnormal indications on the number two engine instruments. After shutting down the engine, they noticed a depletion of the fluid quantity in all of the airplane's three hydraulic systems and reported to the Minneapolis Air Route Traffic Control Center that they were having difficulty controlling the airplane. The captain declared an emergency and requested routing to the nearest airport.

The flightcrew noted that some control of the airplane could be achieved by varying the thrust on the number one and number three engines. Although they were able to direct the airplane toward the Sioux City, Iowa airport and establish a descent profile for a crash landing on the airport, without use of the aerodynamic control surfaces, they could not control airspeed or make rapid corrections in the airplane's descent rate and roll altitude.

During the landing, the right wing struck the ground and the airplane cartwheeled and caught fire. One flight attendant and 111 passengers died as a result of the accident.

The investigation has determined that most of the first stage fan rotor assembly had separated from the number two engine in flight. The separation, fragmentation, and forceful discharge of the fan rotor parts inflicted shrapnel damage to the empennage of the airplane, including severed hydraulic lines.

Of major importance is the need to identify the precise cause of the fan disk separation on the flight 232 CF6 engine. To date the separated components have not been found, although an intensive search effort of fields in the area where the separation occurred continues.

The Safety Board has conducted computerized trajectory analyses to establish the probable location of parts and has used infrared-equipped airplanes to pinpoint debris in corn fields and bean fields. Ground search teams have been into many of these areas without success. We are hopeful that the parts will be found during the farmers' harvest of the fields.

The evidence of parts that remained with the airplane and other parts found in fields indicate the possibility that the failure was initiated in the first stage fan disk. Consequently, six other disks that were manufactured from the same material lot as the accident disk have been undergoing detailed immersion ultrasonic examinations, as well as other non-destructive testing, at the General Electric facility. All but one of these disks and others that have been inspected since the accident have been free from metallurgical flaws. One of the disks did have a metallurgical anomaly, the significance of which is being thoroughly analyzed by other tests.

Although the failure of the fan disk may have resulted from a unique problem, the Safety Board has recommended that the FAA take action to assure the safety of the General Electric CF6-6 engine. The recommendations will be submitted for the record.

The FAA, of course, has been participating actively in the Safety Board's investigation, and we anticipate that it will act promptly when sufficient information is available to define responsive corrective actions to assure safety of the DC-10s equipped with the CF-6 engines.

I mentioned earlier the uncontained engine failure of the Northwest DC-10 just 21 days after the Sioux City accident. I wish to point out that the two events are not related, since the Northwest DC-10 fleet is equipped with Pratt and Whitney JT9D engines. The investigation of that incident has focused on the fracture of a previously repaired fan blade which exited the engine cowling but inflicted only minor damage to the airplane structure. Corrective actions are underway to inspect other fan blades with similar repairs.

As with all of the wide bodied airplanes, the movements of the flight control surfaces that control the DC-10 airplane in pitch, roll, and yaw are accomplished by hydraulic actuators because the control loads are too high for direct mechanical actuation by the pilot. The certification basis for the airplanes require that after any single system failure, sufficient redundancy exists to redistribute the functions of the failed system so that the airplane can be safely controlled.

The DC-10 complied with the certification requirements by dividing the power to the primary flight controls as well as the wing flaps, landing gear, wheel brakes and nose wheel steering among three independent hydraulic systems. The design is such that, in the event of a loss of any one of the three hydraulic systems, the airplane can be flown with little degradation of controllability. Even in the event of a loss of two of the three hydraulic systems, the remaining system will provide sufficient flight control to land the airplane safely. Both the Boeing 747 and the Lockheed L-1011 have four independent hydraulic systems, but these airplanes also have proven to be vulnerable to multiple system failures.

Although the airplane certification rules require hydraulic system redundancy, the rules do not provide for the protection of systems in the event of major airframe structural damage such as occurred on flight 232. Total protection of structure and systems under such circumstances has been considered by the industry to be impractical because of the high energy during failures of heavy rotating engine parts. Further, the hydraulic and flight control systems of all airplanes are vulnerable when serious structural damage such as that inflicted by an uncontained engine failure occurs. This is particularly true when damage affects the empennage where multiple systems are needed to operate elevator, rudder, and horizontal stabilizer controls.

Clearly, a failure of high energy rotating engine parts is an intolerable event and the engine components are supposed to be designed with a safety margin that makes such failures improbable during the allowable life of the parts. Nonetheless, the Safety Board believes that the lessons learned from an Eastern L-1011 fan separation in 1981, a Boeing 747 aft pressure bulkhead failure in 1985, and the United DC-10 accident, can be used to improve flight control systems so that the airplanes are more tolerant to massive engine failures.

In fact, design changes were made to the Boeing 747 empennage structure and control systems following the 1985 accident, and improvements to the DC-10 empennage and control systems currently are under consideration.

To date the Safety Board has found no instance wherein specific components or design areas of the DC-10 do not comply with FAA certification requirements applicable at the time of manufacture. This is not to say, however, that the certification process and the design of these airplanes cannot be improved. The lessons learned from accidents are often the impetus for such improvements, and we hope that will continue.

Another accident, fortunately nonfatal, involving a DC-10 airplane has already led to a review of certain certification procedures and industry changes.

In May 1988, an American Airlines DC-10 was declared a total loss after it overran the runway as a result of a rejected takeoff from the Dallas-Fort Worth airport. The airplane was near its maximum gross weight for takeoff with 251 people on board and fuel for the flight to Frankfurt, Germany. There were no fatalities, but two of the crew were seriously injured in the accident and five passengers were seriously injured in the subsequent evacuation.

The airplane had just reached the V_1 go-no-go decision speed when the captain rejected the takeoff because of a takeoff warning alarm that was later determined to be a nuisance warning. The airplane decelerated for about six seconds after which the deceleration perceptibly decreased and an overrun became inevitable. The accident could have resulted in more serious injuries or loss of life had the airplane not been stopped by soft ground beyond the end of the runway.

An examination of the airplane's brakes and the runway surface after the accident disclosed that eight of the ten brakes had failed during the early part of the attempted stop. The brakes had all been within acceptable condition -- as approved in the carrier's maintenance program -- for continued use before the flight, but the friction material of those brakes that failed had been worn to the point where replacement would have soon been required. The brakes could not withstand the heat introduced by the energy of a rejected takeoff and failed as a result of the

accelerated wear imposed by the resulting high temperature. In fact, when the remaining friction material was depleted, some hydraulic pistons that force the friction material and steel disks together came out of their cylinders and caused a total loss of brake hydraulic pressure so that no further stopping force was attained by those wheels.

New airplane braking performance is demonstrated during initial FAA certification only with all new brakes. In subsequent line operations, brake wear limits are set somewhat arbitrarily, and before this accident there apparently was no consideration given to the differences in heat transfer characteristics of brakes after they are worn. Since this accident, there have been numerous tests using dynamometers to evaluate the performance of worn brakes. The results indicate that the airplane's stopping distance may be greater than suspected with worn brakes even though the design and brake wear limits permit a full stop without failure.

This problem is likely not unique to the DC-10. Thus, we believe that a complete review is necessary of the brake performance and certification requirements for existing and new transport category airplanes, with attention to the establishment of performance standards for brakes that are worn, but within acceptable service limits.

In summary, the Safety Boards' accident investigations do not indicate that the DC-10's certification and operating history is uniquely different from that of other wide body transport category airplanes. While, in retrospect all of these airplanes may have benefited from some design improvements, their operating records have placed them among the safest airplanes in history.

That completes my statement, Mr. Chairman. I would be pleased to respond to your questions.

Senator FORD. Mr. Chairman, one of the main things we wanted today was to try to find out if the DC–10 is safe, and if it is, why. We have heard a lot of technical expressions here this morning and we begin to talk about various and sundry parts of an airplane that are not very familiar to the flying public.

Is there any way that you could make a layman's statement this morning that would indicate that the DC–10 as it relates to the National Transportation Safety Board, as Admiral Busey did a few minutes ago, that—you all basically have said the same thing, but is there a way we could just express that safety? Would you take a shot at it?

Mr. KOLSTAD. Certainly, senator. I guess I do not know how to say it any clearer than just simply stating that we believe the airplane is safe. We found no fundamental design flaws that would suggest a common thread with other accidents. We see no basis for any consideration of grounding. We see no reason for the public to be concerned about flying on this aircraft.

Senator EXON. Would you yield right there for just a second?

Senator FORD. Of course.

Senator EXON. Let me ask you this specific question, if I might, on the Chairman's point, Mr. Kolstad. If any of the commercial airline manufacturers came up with a new airplane today that had so much of the hydraulic system centered in one critical part of the airplane, as is the case with the DC–10, would your agency not have some concerns with that?

Mr. KOLSTAD. Senator, the design of the hydraulic systems on each of the aircraft are somewhat different, although similar in some basic ways. There are improvements being made to the DC–10 hydraulic system, as you know, and there are changes being made to the MD–11, which is the next generation DC–10.

We would not be basically concerned, I do not believe, unless we found something that represented a basic flaw in the design, and as of yet we have not found such a flaw. We have never had a failure as occurred at Sioux City.

Senator EXON. Thank you, Mr Chairman.

Senator FORD. Let me—I probably should have directed this to Admiral Busey, but apparently military aircraft use stronger materials—I say, apparently stronger materials—round the engines to shield the control lines from failures such as the Sioux City occur-

rence. Is there any consideration being given in your inspection as it relates to stronger materials surrounding the lines and the engines?

Mr. KOLSTAD. Senator, I am not familiar with military aircraft. I know there has been consideration given to more shielding. There is a tremendous weight penalty. The basic design has been led toward the nonfailure of that front disk. It has never occurred before.

The engines on the DC-10 are located in such a way that if you had a failure, the parts that might become uncontained are designed to exit in locations that would not sever hydraulic lines. Now, that goes for both the wing engines and the engine in the tail.

Senator FORD. Do you agree with the time frame FAA has established for the CF6-6 engine inspections?

Mr. KOLSTAD. Senator, that AD I believe just came out this morning. We have not really had a chance to take a look at it, but I would be happy to get back to the Committee after we have had a chance to examine it.

Senator FORD. I would ask you to give me a written couple of paragraphs—it does not have to be an elaborate thing—that you agree with their established time frame, and if we can be assured of the safety of the engines in operation until the inspection is completed.

The admiral advised us this morning how he was going to phase in, I believe, the first 65 engines. They have already gone through 25 of those and it seems that he is progressing rapidly to get to some answers from the accident in Sioux City. So if you would do that for me I would appreciate it very much.

Mr. KOLSTAD. I will be happy to.

[The following was subsequently received for the record:]

The Airworthiness Directive, which was effective October 7, 1989 requires inspection of the CF6-6 engine and establishes an ultrasonic inspection requirement for those stage 1 fan disks which were manufactured from titanium alloy material produced using the same processes as those used to provide the raw material from which the failed disk of United flight 232 was made. The basis for the AD was the finding of metallurgical imperfection in the titanium alloy of other disks manufactured from the same material lot.

The AD specified a priority for inspection based upon an evaluation of the susceptibility of the disks to the same metallurgical imperfection as evident in the companion disk. Two types of ultrasonic inspections were defined—an immersion ultrasonic inspection requiring removal of the disk from the engine—and a contact ultrasonic procedure which can be performed without engine teardown but with lower probability of detection of minute imperfections. For disks inspection using the latter procedure, a periodic reinspection requirement was established.

The timeframe for the required inspections appeared to be reasonable, based upon the ability of the operators to comply with the AD and the confidence in the low probability of repeated failure gained by the 18 years service history of the engine.

Subsequent to the issuance of the AD and the conduct of the subcommittee hearing, on October 10 a major portion (approximately 70 percent) of the failed disk from flight 232 was found during the Iowa corn harvest. On October 13, a second piece of the disk was found. The two pieces comprise nearly all of the disk. Preliminary examination indicates that the disk fractured as a result of fatigue which originated from a metallurgical imperfection on or near the bore surface. A comprehensive investigation of the source of the metallurgical imperfection and the associated fracture mechanics is continuing. However, it is possible that the ultrasonic inspection techniques defined in the AD may have to be augmented by further inspection requirements using techniques with higher detection probabilities of surface flaws.

Senator FORD. Do you believe the changes announced by McDonnell Douglas on Friday should be mandated by the FAA, and should there be a time compliance?

Mr. KOLSTAD. Yes.

Senator FORD. That is a good answer. We do not get many of those around here. Like the fellow said, the answer is yes, but it is going to take me a little while to make it.

Does your preliminary investigation of the accident to date suggest any actions that could be taken via the FAA to enhance safety?

Mr. KOLSTAD. Senator, I do not believe so. We made a recommendation immediately following the accident that called for the FAA to take a number of steps involving the inspection of this engine. I believe, with Mr. Laynor's backup, that they are taking action on every one of the areas that we recommended. Is that true?

Mr. LAYNOR. Yes, sir. I think so. Part of the problem is in not having found the disk for the accident engine, and the investigation has taken time to ascertain whether there is a possible material problem, but it is going to require more inspections of the accident disks—the disks from the same melt and other disks. I think, as the history becomes known during the inspection process, we will be looking for further action.

Senator FORD. I understand General Electric is doing everything possible. They have run into some problems that, like soybeans in a field, that is inability to use technology to find the metal in the fields, and that they are going back in after the crops are harvested to see if there is an opportunity to find some of the metal that could be almost anywhere in a large, large area. I compliment them on trying to find it and you for assisting them in that work.

Has the Transportation Safety Board ever recommended any changes or modifications to the DC-10 to FAA that have not been adopted?

Mr. LAYNOR. Well, the only recommendation that goes back to the 1974 Turkish Airlines accident, the Safety Board at the time did recommend changes to the DC-10 cargo door after an American Airlines accident a couple of years before the Turkish Airlines accident, in which the FAA did not take air worthiness corrective actions, and that became quite an issue after the high loss of life in the Turkish accident, but that is the only case that I can recall now where the FAA has not taken action to correct a deficiency in the airplane.

Senator FORD. Mr. Kolstad, as I understand you in your statement, all of the DC-10 accidents outside the continental United States that occurred, only one was operation—could be pointed to operation of the aircraft?

Mr. KOLSTAD. Only one could not, Senator.

Senator FORD. Only one could not?

Mr. KOLSTAD. Yes, sir.

Senator FORD. In your testimony I believe you said in retrospect, all of these planes may have benefitted from some design improvements. Do you have any suggestions to improve the process for improving the aircraft design so that all improvements are not retrospective?

Mr. KOLSTAD. No, Senator, I do not. We might have as we get further along in the investigation. But at this point, no.

Senator FORD. Senator Danforth.

Senator DANFORTH. No, questions, Mr. Chairman.

Senator FORD. Senator Exon.

Senator EXON. Mr. Chairman, thank you very much.

Mr. Kolstad, let me follow up on a question that Chairman Ford asked of you. You said that you were not familiar with the difference between the specifications and the construction of certain military aircraft with regard to protection around engines and commercial aircraft. I believe that was your response, right?

Mr. KOLSTAD. Yes, Senator.

Senator EXON. Would you please, for the record, check that?

Mr. KOLSTAD. Certainly.

Senator EXON. And submit that information back to the committee. Because as Chairman Ford said, we certainly do not want to be alarmist here, but there has been a great deal of concern in this whole area.

[The following information was subsequently received for the record:]

The Safety Board's staff has been informed by those major airframe manufacturers who produce similar versions of military and commercial airplanes, such as the KC-135, EA-6, KC-10 and airborne command and control aircraft, that the engine installations and protection against liberation of high energy parts are essentially the same, and in some cases, identical for both versions of the airplane. Furthermore, we have been told that the level of flight control system redundancy and the protection afforded to flight control components is the same for both aircraft.

Senator EXON. And while I recognize that the testimony of you experts is somewhat highly technical, what we are trying to do is just get through all of that technical talk that we hear and have something said that is clearly understood by the public at large. I think the public at large, today, needs some reassurance on these matters. And maybe you could answer this question for me.

Is there any other aircraft flying today, where, if one, two or three or more hydraulic lines were severed that that would cripple all of the hydraulic lines on the aircraft? Or, to put it another way, correct me if I am wrong, as I understand it from reading the reports on the tragedy at Sioux City, that airplane was landed without any hydraulic controls at all; is that right?

Mr. KOLSTAD. That is correct.

Senator EXON. My question, then, to you is could this happen on any other design of aircraft? Is that possible?

Mr. KOLSTAD. Yes, sir, Senator, it is.

Senator EXON. Has it happened previously, to your knowledge?

Mr. KOLSTAD. Yes, it happened in a JAL accident involving a 747 in Japan.

Senator EXON. That was in Japan, the one that flew into the mountain?

Mr. KOLSTAD. That is correct.

Senator EXON. And what was the reason for that failure?

Mr. KOLSTAD. The failure of the aft pressure bulkhead, which basically allowed the pressurization of the aircraft to destroy the hydraulic systems that were in the empennage of the airplane when the aft pressure bulkhead failed.

Senator EXON. Well, redundancy is certainly a much wanted thing in aircraft safety, recognizing that it would be more expensive to construct.

Then what you are telling me is that we cannot control everything, but other types of aircraft than the DC–10 could have a failure of the hydraulic system and we do not have much redundancy in that area?

Mr. KOLSTAD. We have redundancy, Senator. It is an extremely improbable event, but it is possible, which I think was your question.

Senator EXON. We do not have, on our modern-day aircraft, any wires that could manually control the tail or the other important elements of that aircraft, with regard to steering it and bringing it down? If the hydraulic system fails, that is it; is that right?

Mr. KOLSTAD. Yes, Senator, that is it.

But let me just point out that even if you had wires, wires can also be cut. Hydraulic systems do not usually fail in multiples. It is just an extremely rare event.

Senator EXON. I will be looking very forward to the information that you come back with on whether there is a significant difference with regard to shielding of those critical elements of controlling an aircraft between commercial and military aircraft.

As a member of the Armed Services Committee, I know we spend more money per aircraft than do the commercial airlines. And we are criticized on that from time to time, but I would think that if there is anything at all to that theory that has been raised here in the line of questioning to you this morning, it is something we ought to look into.

Mr. KOLSTAD. Okay, sir.

Senator EXON. Thank you.

No more questions, Mr. Chairman.

Senator FORD. Thank you, Senator Exon.

I believe Admiral Busey said earlier in his testimony that the design of the DC–10, under the circumstances, allowed it to be maneuvered with power. Even though the hydraulic system was out, the design of the DC–10 allowed it to be maneuvered somewhat with powering of the engines that were left.

Mr. KOLSTAD. That is correct.

Senator EXON. Would that not be true with any aircraft?

Mr. KOLSTAD. It depends upon what the failure mode is, Senator. It is hard to generalize on things like that.

Senator EXON. Well, but I mean the pilots controlled that aircraft by getting it at least on the ground, as I understood it, by just speeding up one engine and reducing the other.

Mr. KOLSTAD. That is correct.

Senator EXON. And pulling it through the air.

Mr. KOLSTAD. That is correct, sir.

Senator EXON. And the only way that they had to land that airplane, as I understood it, was to take a shot at it and control it by just the speed that they hit the ground. And there was not anything else they could do with it under the circumstances, is that correct?

Mr. KOLSTAD. That appears to be the case.

Senator EXON. Thank you.

Senator FORD. Thank you, Mr. Kolstad. We appreciate you and Bud coming this morning, and look forward to working with you more in the future.

Mr. KOLSTAD. Likewise, Mr. Chairman. Thank you.

Senator FORD. The next witness is Mr. Dale Warren, Vice President of Engineering, McDonnell Douglas Corporation.

Good morning, Mr. Warren, we appreciate your being here this morning and look forward to your testimony.

And Senator Exon and I will probably have some questions for you. You may proceed.

STATEMENT OF DALE WARREN, VICE PRESIDENT OF ENGINEERING, McDONNELL DOUGLAS CORP.

Mr. WARREN. Thank you, sir. I appreciate the opportunity to be here and testify before this committee on behalf of the McDonnell Douglas Corporation.

I have submitted a relatively in-depth statement for the record, and I would like to summarize some of the key points.

Senator FORD. Mr. Warren, your statement will be included in the record and we will appreciate your summary.

Mr. WARREN. The first point I want to make is that the DC-10 is a safe airplane. You have heard that twice before and I would like to point out some facts that have not been brought up before.

Eighteen million engineering hours were used in the development and certification of the DC-10. A large share of that was spent in checking and rechecking the design to be certain it was correct. Very sophisticated testing was done in the laboratory and also in flight to verify that design.

In addition to that, the certification, as done by the FAA, has been endorsed in one way or another by the regulatory agencies in seven other countries worldwide--very thoroughly evaluated and reevaluated.

In addition to that, the DC-10 has gone through special reviews by special committees commissioned by the administrators in past times.

Another point I would like to make is that MDC is a good citizen in our industry. The example with which I am most familiar is the DC-9 fuselage number three extended service life testing. Ten years ago before aging aircraft was a byword in the media and other places, we recognized that this was a concern and we purchased out of service a 20-year-old airplane and put it in the laboratory and subjected it to another 50 years of simulated service.

This came at some expense to us, but we felt that that was a very proper investment towards the long-term air safety associated with our airplanes.

Another thing that is not well-known is that we are continually improving our designs. One would think by reading the more publicized information that the only time the airplanes are changed is when there is an accident. And this is absolutely untrue.

For the DC-10, during a normal period—I will cite two years ago as a good example—the change traffic is about 1,000 changes per year. Now, a good portion of those, perhaps half, are associated with special changes to customize a series of airplanes for special

customers. But a large fraction of that 1,000 changes per year goes to improving the airplane in a variety of ways.

Three that are significant in this conversation is that we make changes to make the manufacturing process work better and that improves the quality of the product, and thus, safety is enhanced.

We also make changes to make the operation of the airplane easier for the flight crew, and this improves safety.

And thirdly, we make changes to make the maintenance of the airplane more straightforward, and that also improves safety.

We announced last Friday a safety enhancement for the DC–10. It is our response to the Sioux City accident, not intended to be really relevant to other cases that you can imagine. And I will discuss that in a little bit more depth.

First, the change itself amounts to three basic elements. One of them is a valve installed in the aft fuselage in the number three hydraulic system. Another one is a sensor that is installed in the reservoir for the number three system. And the third part is an indicator on the panel for the flight engineer in the cockpit.

The function of this is that in the event of a massive strike just as the Sioux City scenario, the sensor in the reservoir will detect a loss of fluid in the number three system. This will trigger a closing of the valve in the aft fuselage, and the closing of the valve will, in turn, illuminate the indicator light on the flight engineer's instrument panel.

The significance of this in terms of the Sioux City accident is that if this enhancement had been installed in that airplane prior to that accident, the pilots would have had a relatively easy time making a safe landing with that airplane.

We have verified this with simulation. The simulation required the development of some procedures, and we have consistently made safe landings using the simulator to evaluate that technique.

The timing for this process, as we can best estimate today, is 21 months to complete the enhancement of the entire fleet. And for that time, the estimate is based on nine months for procurement of parts and 12 months for installation in the entire fleet of over 400 airplanes.

This has been the work of a DC–10 task force, with membership of engineers and other people from McDonnell Douglas, with representatives from key customers for the DC-10, both in the United States and abroad, and also with FAA involvement.

The task force is a lead element of the industry/government task force that was recently chartered by the FAA. My perception is that, in the same way that the aging aircraft activity has been extremely well handled in the last year in the industry/government task force, we should have high expectations for significant improvements in general air safety as a result of this group chartered by the FAA.

My thanks for the support of this committee to our industry. And I would be happy to answer any questions you have.

[The statement follows:]

Statement of

Dale S. Warren
Vice President - Deputy Gen. Mgr. - MD-11/DC-10
Douglas Aircraft Company
McDONNELL DOUGLAS CORPORATION

September 19, 1989

Mr. Chairman, members of the Committee:

I am Dale S. Warren, Vice President - Deputy General Manager, MD-11/DC-10 Program, for the Douglas Aircraft Company component of McDonnell Douglas Corporation.

On behalf of my company, I want to thank you for this opportunity to address the issues before this subcommittee today. My qualifications include BS and MS degrees in Civil Engineering from the University of California at Berkeley, specializing in structures, and 35 years of experience at Douglas in the design, development and in-service support of large jet aircraft.

I would like to address four principal topics that I believe will cover the matters of concern to this Subcommittee:

* Changes to the DC-10 design that have been made in the past;
* Improvements we have developed in follow-up to the tragic accident at Sioux City, Iowa on July 19;
* Our participation in the work of the joint Goverment-Industry Task Force formed by the FAA following Sioux City;
* And the matter of the certification basis for our new MD-11.

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GENERAL REMARKS

To begin, however, I would like to make a few observations about McDonnell Douglas and our products, for the record.

First, the DC-10 is a safe aircraft. Eighteen million hours of engineering went into the original design and development; a large fraction of this was spent checking and double checking the design. Sophisticated testing was done in the laboratories and in flight to verify every aspect of the aircraft. The DC-10 certification by the FAA has been confirmed by major regulatory agencies world-wide, including the CAA (Great Britain), RLD (The Netherlands), DCAC (France), FAO (Switzerland), TC (Canada) RAI (Italy), LBA (German Federal Republic) and JCAB (Japan).

Additionally, the FAA certification process and the DC-10 design were reviewed by special committees created by the FAA Administrator.

Second, McDonnell Douglas Corporation is a good citizen of our society, as a matter of traditional policy and continuing practice.

As an example, MDC sets very high standards for the structural life and the integrity of our products. In keeping with that, as a special program over and above any regulatory requirements, a used DC-9 was purchased out of airline service after 66,500 flight cycles and subjected to additional simulated usage in the laboratory, to a total of 208,000 flight cycles. It was done because we were intent on gathering significant data to support additional safe use of our aircraft in airline service. And it was done years before the world's attention was focused on the issues of aging aircraft.

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McDonnell Douglas also has done several related things: 1) the Supplemental Inspection Documents (SIDs) defining additional structural inspections required for extended life usage of our DC-8, DC-9 and DC-10 aircraft; 2) a voluntary in-the-field Design Evaluation Program to accelerate engineering understanding of the real-life environment our aircraft operate in, to facilitate design improvements for better maintenance of our products; and 3) active participation in the government/industry task force on Airworthiness Assurance (formerly Aging Aircraft) which is addressing close-out of key service bulletins, improved corrosion control and improved standards for field repairs to ensure continued safe and efficient operation of jet transports as they get older.

Obviously, I and all of us at McDonnell Douglas are very proud of our company and our products. I cite these examples to help define the overall context for the discussion that follows.

CHANGES TO THE DC-10 DESIGN

It is and always has been our practice to continually improve our aircraft as long as they remain in production, and throughout their operating lives. There is a steady flow of changes that begins with service experience or the development of new technology, crosses our drawing boards and goes into the fleet through the assembly line or as modifications in the field. We are organized for that product improvement activity as part of our regular routine.

On our DC-10, there have been many such design improvements, for many different reasons. I will mention several to illustrate.

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Cargo Door Redesign

In 1972 and '73 we redesigned the closing and latching mechanism on DC-10 cargo doors in response to two incidents in which the door on the aft bulk cargo compartment came open as the aircraft was being pressurized, despite appearing to be securely closed. One of these events occurred during a ground test; in the other the aircraft was climbing after takeoff. In the second instance, the depressurization caused the cabin floor to buckle above the open door, damaging control cables to the tail of the aircraft. The pilot nevertheless was able to return to the airport for a safe landing. There were no injuries to anyone on board.

While retaining the basic latch, lockpin and pressure vent of the original door design, we revised the mechanical linkages activating them into what we call a "closed loop" system. This makes it impossible for the pressure vent to close -- thus preventing pressurization of the aircraft -- unless the latches are properly set and secured by the lockpins.

This new door design was installed on aircraft on the assembly line in 1973, and was offered for retrofit on those already delivered.

The "closed loop" door was not installed on the DC-10 involved in a major accident in France in March, 1974. In that case, the aft bulk cargo door came open in flight as the aircraft was pressurized after takeoff, causing collapse of the cabin floor and crippling control lines to the tail. The aircraft was lost with everyone on board.

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Investigation of that accident showed the latch-lockpin mechanism was so misrigged that the pressure vent could be closed with the latches in an unsafe condition, and also so that a cockpit warning light that should have alerted the crew was not functional. Following those discoveries, the entire DC-10 fleet then operating was retrofitted with "closed loop" cargo doors on an accelerated basis, and we also improved the warning system with additional redundancies.

Cabin Floor Pressure Vents

The 1974 accident near Paris also resulted in recognition and resolution of a design issue peculiar to all large, wide-body airliners -- the tremendous structural loads imposed on the cabin floor in the unlikely event of a rapid depressurization through an opening in the lower fuselage. It was those loads that caused collapse of the floors in the DC-10 incidents cited here.

Our study of the issue led us to adopt as standard on all DC-10s a heavier, more rugged cabin floor structure originally designed only for convertible freighter models.

It also led to development and industry-wide adoption of a system of pressure vents installed at floor level throughout the aircraft cabin. These will spring open instantly if the aircraft depressurizes below the floor, venting pressure in the cabin to prevent a pressure overload on the floor. The vents designed by McDonnell Douglas were accepted as an industry standard, were built in to all new production DC-10s, and were retrofitted in all DC-10s then in service as well as in other manufacturers' aircraft.

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Redundant Stall Warning and Slat Position Indicator Systems

There were several changes following the May, 1979 accident at Chicago in which an aircraft was lost when the pylon and engine separated from the wing during takeoff. Study of that accident showed the pilot maintained control despite severe damage to the right wing, until speed was reduced in accordance with standard engine-out procedure and the aircraft went into a stall from which it did not recover.

The design changes involved wiring for the stall warning system and stick-shaker, providing redundancy to assure continued availability even with the physical loss of an engine; an improvement to the slat position indicator system that cross-links sensors to preclude loss of indicator function; and replacement of two raised-head fasteners in the pylon aft bulkhead with recessed or flush fasteners, to provide additional clearance between the pylon and its wing attachment during pylon installation.

We also developed -- and FAA mandated the use of -- a special alignment tool to protect the pylon from inadvertant damage during installation or re-installation after removal for maintenance.

In addition, takeoff/climb speed procedures in the aircraft operating manual were revised to provide increased stall margins with an engine out.

Leading Edge Slat Lock-out

Service experience also led, in 1982, to modification of the DC-10's leading edge slat system. The change was not related to the Chicago accident, but resulted from a 1981 incident of external damage to the slat system which caused some segments of the slat to retract on one wing, while those on the other wing remained extended.

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Slats are devices installed along the leading edge of the wing, extended on takeoff and landing approach to give the wing extra lift at slow speeds. The DC-10 is designed to be, and has been demonstrated to be, fully controllable with such an asymmetric slat condition. The incident leading to this change did not result in any accident, but we acted to preclude uncommanded slat retraction caused by damage to the leading edge of the wing.

One modification made consisted of installing hydraulic valves in the leading edge that will act as locks to keep the slats extended if the hydraulic lines to the slat actuators are severed and pressure is lost in the actuator. As a back-up to that, we installed springs in the cable system controlling the slat actuators, to keep the actuators in the extended position and prevent inadvertant retraction of the slats even if the control cable is broken.

Wheels and Tires

We have also, over time, implemented a number of changes to the DC-10 landing gear wheels and tires to improve performance and safety margins.

These include development of heavier wheel rims to protect against wheel break-up or other damage in the event of a violent tire blow-out, and on-the-wheel tire pressure gauges that provide a sure check of proper tire inflation during pre-flight inspections.

We were the first in the industry to introduce a tire pressure indicating system installed in the cockpit, to supplement tire checks made during the walk-around inspection.

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And we also have made more than a dozen design improvements to protect control, hydraulic and electrical systems in the aircraft from damage that might be caused by a tire blowout.

All of the foregoing list of changes is only representative of continuous product improvements made to the DC-10 design. We constantly generate design enhancements, and we have never hesitated to incorporate any that contribute to safety, whether or not they may be required by regulation. Our people pride themselves on being ahead of regulatory requirements.

IMPROVEMENTS FOLLOWING SIOUX CITY ACCIDENT

In keeping with our policy, immediately after learning the nature of the Sioux City accident last July 19, McDonnell Douglas began a review of the current hydraulic system installation on the DC-10, to identify any design change that could further assure the integrity of the control systems.

Initially the research centered on ways to provide an increased margin of controlability in the event of a massive failure of the Number 2 engine. The energy involved in the loss of the fan assembly as seen in the accident at Sioux City is comparable to stopping a 3000-pound automobile traveling at 200 miles per hour.

Preliminary findings in that accident investigation indicated there were 75 distinct and widely separated impacts by engine parts on the horizontal stabilizer. The stabilizer has a span of 71 feet, and is more than 20 feet across at its largest chord. It actually has a larger aerodynamic surface than the wing of a DC-3.

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We have never witnessed, in 30 years of jet airliner experience, an engine failure of such violent magnitude, and we surely don't expect to see another.

However, we believe the prudent approach, after witnessing such an event, is to determine if there are any additional measures that can be taken to enhance the aircraft's survivability in such circumstances.

Working with several major DC-10 customers as an initial task force, and with observers from the Federal Aviation Administration, McDonnell Douglas developed a design improvement that will help ensure a safe landing in the event of a repeat of the Sioux City engine failure including loss of all three hydraulic systems.

This enhancement can be equated to the safety equipment installed in automobiles to improve survival in accidents, such as the addition of airbags to supplement existing lap belts, shoulder harnesses and padded interiors.

In the case of the DC-10, the widely separated and well protected redundant hydraulic systems provide the primary protection. The enhancements we announced last week can be likened to the airbag, providing still another measure of protection that will allow the aircraft to be flown safely even if the worst-case, one-in-a-billion incident occurs.

The elegantly simple design provides for the addition of an electrically operated shutoff valve in the Number 3 hydraulic system. This valve will be installed on the supply side of the system, in conjunction with a one-way check valve on the return side.

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The shutoff will be initiated by sensors in the Number 3 hydraulic reservoir in the right hand wheel well; these will detect a decrease in the fluid level and activate the electrical switch to close the valve, thus preserving the integrity and function of the Number 3 hydraulic system. A unique aspect of this design is that it provides for detection and response to slow fluid loss rates as well as massive leaks from major damage.

Finally, a warning light installed on the flight engineer's panel in the cockpit will illuminate when the shutoff valve has been commanded to close, indicating status of the Number 3 system.

With hydraulic flow to the tail section stopped, the Number 3 system, the "preferred" system (because of its shorter tubing runs and well protected location), will continue to power key controls, allowing a safe landing even if it is partially damaged in the tail along with the Number 1 and Number 2 systems. This system also operates brakes, landing gear and segmented wing control surfaces.

This design has been tested in a DC-10 flight simulator modeling the DC-10 with these enhancements and the kind of extensive damage seen in the Sioux City accident. It has consistently allowed for a safe approach and landing with standard piloting techniques.

Airlines were involved in developing this new enhancement to the DC-10 hydraulic system, and our largest DC-10 customers endorse it. We are working with our suppliers, the airlines and the FAA to determine installation timing and costs. Plans call for the new valves and related equipment to be installed in all DC-10s within 21 months. In addition, new flight operational procedures and engine inspections are being studied as supplements to the hydraulic system improvements.

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TRANSPORT AIRPLANE SAFETY SUBCOMMITTEE

Carrying on in the pattern established by the highly effective Airworthiness Assurance Task Force dedicated to Ageing Aircraft and related issues, FAA Administrator James Busey called for the establishment of a new government/industry task force to examine large aircraft design and safety issues associated with severe damage encountered in flight.

All three of the U.S.-built wide-body aircraft have suffered such damage, and a prudent engineer always will build on the growing body of service experience as well as new design technology to seek additional safeguards.

McDonnell Douglas heartily endorses this task force team approach. I personally believe the achievements of the task force on Airworthiness Assurance already represent one of the best actions to occur in our industry in the past 30 years.

This group, bringing together the best technical expertise in the world in this field, has combined the efforts of government, manufacturers and operators in the U.S. and abroad to address head-on the worldwide concerns dealing with the continued service of ageing aircraft.

By making certain service actions mandatory as aircraft reach the appropriate milestones, the Airworthiness Assurance Task Force has taken positive steps to prevent catastrophic safety-related structural failures from occurring as aircraft get older.

We believe the recommendations of the new Transport Airplane Safety Subcommittee will provide safety design benefits of the same significance to the whole air transport industry and to the flying public.

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The task force is being organized as the Transport Airplane Safety Subcommittee of the FAA's Research and Development Advisory Committee. Serving as chairman of the Subcommittee is Robert Aronson, president of the U.S. Air Transport Association.

Systems Working Groups involving the major elements of the air transport system -- manufacturers, airlines, pilots, regulatory agencies and passengers -- are being established for each of the main families of transport aircraft.

The working groups will send their results to the Transport Airplane Subcommittee, which, in turn, will advise the FAA.

Following the Sioux City accident, McDonnell Douglas moved as swiftly as possible to assemble the lead elements of a DC-10 systems working group. The recommendations concerning installation of new hardware in the DC-10's hydraulic system to aid controllability of the aircraft after damage from a catastrophic engine failure, described previously, were reviewed by these elements.

A meeting to begin organization of the full Transport Airplane Subcommittee is planned this week in Seattle, Washington. It is expected that this Subcommitte and its Systems Working Groups will remain active to study safety-related, broad-based design issues after the basic work on controllability has been completed.

MD-11 CERTIFICATION

The MD-11 is the newest member of the long line of McDonnell Douglas commercial transports, and indeed the newest airliner now in development in the United States. It is the successor to our DC-10 as a long-range, wide-cabin luxury tri-jet. It has met with tremendous market success, with commitments for over 300 aircraft already on the books.

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We began developing the MD-11 over five years ago, and committed to production at the end of 1986. The first several aircraft are now on the assembly line at our factory in Long Beach, and later this year we will begin a year-long flight test program leading to certification by the FAA.

The application for certification of the MD-11 was filed in 1985, as an amendment to the existing DC-10 type certificate for this new model.

The idea of such derivative certification is basic to the regulatory process. It is in the best interest of the travelling public because it is integral to the process of providing safe and effective air transport at the lowest cost, for these reasons:

1) New design and production concepts are evolutionary rather than revolutionary in nature;

2) New design/production concepts become reality only if they are economically viable;

3) The cost of certification is a significant element in the decision to implement a new concept.

Current rules controlling certification of aircraft in the United States and abroad are properly responsive to these considerations. They incorporate flexibility to foster advancements. They recognize and allow for expert judgement as required to make the process of change practical. And they assure a continually advancing level of technology and safety in commercial air transportation.

There have been 45 amendments to the FAA's certification rules since the DC-10 type certificate was issued in 1971 -- including a number implemented since the request for the MD-11 was submitted.

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In preparing for certification of the MD-11, we have carefully worked through all of these amendments, and all are incorporated in the MD-11 design except for four. Three of these four exceptions relate to items that are in the supply pipeline that provides parts for our tri-jets -- a pipeline that has largely continued from the DC-10 to the MD-11, and therefore has a large backlog of parts previously ordered in the system. We plan to incorporate changes reflecting the three exceptions to current FAA certification rules as soon as the flow of parts through this pipeline allows.

The fourth exception to current certification rules involves aircraft operational procedures, and we are working with our operators to develop a way to also comply with that latest rule.

We are doing this with the idea that we may amend our application for FAA certification of the MD-11 to ask for issuance of a new type certificate on this new aircraft, because it is meeting all the current certification regulations.

Further, the MD-11 division of the Douglas Aircraft Company has set a policy that calls for incorporating all future changes to certification rules into our production aircraft as they evolve, assuring that our design will remain current through all the years of production ahead.

Our MD-80 division is investigating the feasibility of also applying this same philosophy.

Mr. Chairman, this concludes my statement. Again, I thank you on behalf of the people of McDonnell Douglas for the opporunity to be here, and I thank you and the Subcommittee for your support of the aviation industry.

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Senator FORD. Thank you very much, Mr. Warren.

The modifications that you announced Friday, how will that be handled? How will those modifications be carried out?

Mr. WARREN. Are you asking the question about who pays for it?

Senator FORD. Well, the modifications that you announced on Friday, how will they be handled? You announced the modification, what is the next step? What happens? Does the owner say yes, I want that put on? Or he says no, I like it the way it is and we will leave it alone?

What is the procedure?

Mr. WARREN. We have not fully completed the design yet. The concept is clearly established. We have yet to do the detailed design and to breadboard the system and write the service bulletin.

I am certain that the FAA will write an airworthiness directive to make that installation mandatory on all airplanes operated in the United States.

That will all be completed in advance of availability of parts, as best we can estimate it today. The key operators have already signed up to do some advance planning to make that installation process go more quickly.

We expect, then, that the installation of parts will start early next summer and be completed about a year from that time.

Senator FORD. Who pays for it?

Mr. WARREN. That has not been discussed really yet. Our only fundamental issue to date has been safety. It is normal practice under these circumstances that the owners of the airplanes are responsible for the maintenance of the airplanes.

Senator FORD. Do the preliminary results of the Sioux City accident suggest any additional test you may develop to detect and prevent some catastrophic failures in the future?

Mr. WARREN. Yes. As the Admiral mentioned earlier, we have several things at work in Douglas, and these are related, and really other lead activities for the industry/government task force.

Our work is broken into two phases. Phase one is to look at those things associated directly with Sioux City. This enhancement pretty well closes that action for the DC-10. We have already started to look at other hazards for other parts of the airplane.

These other hazards include possible massive engine failure at other engine locations, more threatening tire failures than ever seen before, and APU failures. And I expect that the committee eventually will begin looking at possible improvements that might improve the survivability of the airplane after major in-flight damage associated with mid-airs and other in-flight problems.

Senator FORD. But are you referring to the industry/FAA advisory group?

Mr. WARREN. Yes, and also what Douglas has already started.

Senator FORD. Well, this advisory group will, as I understand it, examine large aircraft design and will have its organizational meeting this week. Do you have a schedule that that group might be working under?

Mr. WARREN. I personally do not have a schedule. The first meeting is scheduled for Thursday of this week, and at that time, meeting schedules will develop. The last industry/government task force, working to date primarily on aging airplanes, has been meet-

ing monthly at three different levels and with very active participation by operators, regulatory agencies and manufacturers around the world.

Senator FORD. That is on the aging aircraft?

Mr. WARREN. Yes.

Senator FORD. And what you are saying here, you would indicate something similar to that in the advisory group?

Mr. WARREN. That is correct.

Senator FORD. I asked the question earlier, and Senator Exon had some interest in it also. Have you considered the use of stronger materials to contain engines and vital cables in your aircraft or stronger materials used in the production of your military aircraft as it is compared to the revenue aircraft?

Mr. WARREN. We are in the process of final stages of development of two military aircraft and, as a generality, the standards really are not that much different.

Now, we are not in—at our facility—in the combat aircraft design field, so I cannot speak for that. As a generality, shielding of lines and cables for failures such as the Sioux City accident is almost futile.

The energy associated with the loss of that fan we liken to trying to stop a car, a 3,000-pound car traveling 200 miles an hour. That requires an almost impossibly large shield.

Some shielding is natural because the lines or the hydraulic system lines are buried in relatively heavy structure, and there is a significant amount of shielding. Additional shielding, just as shielding, is not very practical.

Senator FORD. In addition to modification to the hydraulics, McDonnell Douglas has also recommended a number of items, I understand, such as corrosion control, which came out of the aging aircraft task force, which has done very well.

The industry must also install traffic collision avoidance systems, wind shear systems and others. We keep on with these systems to try to make it safer. Is there significant capacity to accommodate all of these changes in a timely fashion and do you foresee extensive downtime for the nation's older aircraft?

Mr. WARREN. We have investigated the loading on the manufacturers and the maintenance specialty organizations worldwide, and I could say that we looked at this because it was a possible business venture for us.

The near term requirements for maintenance associated with high time airplanes is not significant. It does not represent an overload on maintenance facilities.

Some of the other installations like TCAS installations may be a more severe problem, and I am not personally familiar with any data on that situation.

Senator FORD. Senator Exon.

Senator EXON. Mr. Chairman, thank you.

Mr. Warren, thank you for being here this morning. It is not—I want to start out by saying that it is not our cause to have you here just so we could beat up on you. I mean, I think you are concerned about this problem, whether there is a problem, and if there is one, what we can do to correct it or if there is not a problem,

what we can do to make sure that something does not happen again.

I would like to first say that you and McDonnell Douglas are old-line manufacturers of airplanes, and I have a great deal of confidence in you. So much so that within the last month I flew on a DC-3 out of a fishing camp in Canada.

I flew all over in the military version of that C-47 during World War II. I know what a work horse the DC-3 was, and that is part of the history of your organization, and so I know you know how to build airplanes, and I know you want to build them safely.

That also shows how old I am. The difference between me and some of my counterparts is that I admit it.

Senator FORD. You have to admit it around here or they publish it in the paper.

Senator EXON. Oh, by the way, to show you what a good airplane that is, the DC-3, the airplane turned around on a fishing strip just after a very heavy rain, and the pilot got the left wheel off the runway, and it went up to the axle in mud, and we were delayed two hours while they got a Caterpillar and hooked it onto the tail of the plane and pulled it out.

And when they started pulling on that, I thought they would pull the whole back of the airplane out, but it did not, and the DC-3 took off as it always had.

But how much of a problem is this matter of pressurization? You know, that is part of the aging fleet problem. We have had airplanes rip apart in the air and, as I understand it, as a layman, that is primarily due to the stress that is placed on airplanes from takeoffs and landings and pressurizations.

But we could not fly as high as we do without pressurization, and so it is a good thing.

Is there—talking about redundancy again that I referred to in earlier questions—is there a complete and separate system or not with regard to the hydraulic means that we use to pressurize an airplane and the hydraulic lines that we use to fly that airplane?

Mr. WARREN. Essentially no connection between pressurization systems and hydraulic systems for power and controls. And, in—a very simple description is that the hydraulic system on the DC-10 starts with a set of six hydraulic pumps, two on each engine. Those are manifolded into three systems and then those three systems are used in a very special way to provide redundancy and separation to all segments of the control systems.

Segments—to make that clear, the rudder is not just a rudder. It is two rudder segments. The elevator is not just an elevator. It is four elevator segments, and these are all separated and isolated with a lot of redundancy.

The system used to pressurize the fuselage on an airplane is quite different. The technique is to draw power from the compressor stage of an engine. Bleed air it is called. This is used as a power source, and then there is a heat exchanger system that is somewhere in—buried in the airplane out of sight that is used to operate on outside air with some mix of inside air recirculated. And, taking that bleed air power to operate that environmental control system. And so, essentially there is not any real connections.

Both systems are driven by engine power is the only connection.

Senator EXON. If a pilot of a DC–10 aircraft knows that there has been an explosion in the tail section of the aircraft that could potentially cause the loss of hydraulic fluid and, therefore, the loss of the hydraulic system, does he have automatic and manual shutoffs that he can apply to keep the line that had been shattered from draining the hydraulic system? Is that not what happened in Sioux City?

Mr. WARREN. Your description is accurate that that is what happened in Sioux City. The system that we are recommending for all operators to install in DC–10s does not have any manual override characteristics. It is automatic.

Now, to make it clear why that is sensible, you should consider part of the records from Sioux City. The crew had indications within two minutes after the engine failure that they did not have hydraulic power.

Senator EXON. Within two minutes?

Mr. WARREN. That is correct.

Senator EXON. That was a very critical two minutes.

Mr. WARREN. Yes.

Senator EXON. Was there anything they could have done?

Mr. WARREN. They did all the right things.

Now, they did some things over and above the minimum necessary. They had reason to believe that the hydraulics were gone. The gauges told them that the hydraulic fluid was gone, and the feel of the controls told them that they probably did not have much control power, but they continued to operate the controls of the airplane until the landing because they could not be absolutely certain that the hydraulics were gone.

Now, this is an indication to me that having a manual control on a hydraulic system for a shutoff where a pilot might assume that for some indications given to him that there is an engine failure and there may be a line separation that he should shut off the line.

More than likely he would not recognize that in time and would not necessarily make a good decision. So, an automatic system——

Senator EXON. On that particular airplane had he recognized it where there was a manual shutoff, they could have used or not?

Mr. WARREN. Negative.

Senator EXON. Should there be?

Mr. WARREN. We think not because we do not think that should be an added pilot workload.

Senator EXON. You want it to be automatic?

Mr. WARREN. Yes, and that is what we have designed.

Senator EXON. You heard my question, I believe, that I asked the previous witness as to whether or not there was a significant difference in shielding of jet aircraft, a difference between military aircraft and commercial aircraft.

As a manufacturer can you answer that question?

Mr. WARREN. Well, we are building two military airplanes at our facility, a C–17 and a T–45, and all the design concepts are the same. Now, those two are not first-line combat airplanes, and there may be something in a fighter aircraft that we do not know about in the form of shielding.

Generally speaking, as we understand the business of designing combat airplanes, the idea is still that redundancy of systems is by far the preferable technique to provide for reliability.

Senator EXON. My specific question is, and I wonder if you can answer it, whether or not there is traditionally a significant difference or any difference between the military specs and commercial specs with regard to protection of things flying out of the engine if it should blow up or additional protection around the hydraulic lines themselves.

Mr. WARREN. Not on any of the airplanes that we are doing, which includes the C–17 and the T–45, and I could go back further to the C–133 and RB–166.

Senator EXON. They are about the same?

Mr. WARREN. Yes.

Senator EXON. You testified that it is the owner's responsibility after they purchase an aircraft from you for an operation. I can understand that. Certainly, though, the owners do consult and you must send them manuals and memoranda from time to time making suggestions of what you thought should be done and the whole maintenance procedure. I assume that is true?

Mr. WARREN. Absolutely. Extensive documentation of recommended maintenance.

Senator EXON. Let me ask you this question. Are you, as a manufacturer, satisfied with the maintenance that is being performed and the inspections that are being conducted by the assigned federal agencies as far as basic maintenance is concerned, basic or routine or anything else? Are you generally satisfied? Are you satisfied in all cases that all the commercial airlines that use your equipment are doing an adequate or better job of maintenance?

Mr. WARREN. We have an approach to evaluation of maintenance on a worldwide basis, and we worked with the FAA to better understand how maintenance is done in this country and abroad.

As a generality, the maintenance done in this country is significantly better. There are isolated operators outside the United States that are of concern to us, and we are working to try to find ways to ensure that U.S. citizens traveling abroad are not exposed to any dangers associated with that.

As a generality, our impression is that the U.S. operators do a good job of maintenance. Some do a little bit more than others, but as a generality there is good maintenance.

Senator EXON. Mr. Chairman, if I might, my last question has to do and goes back to the hydraulic thing once again.

I have information that I would like to have you comment on that in 1974 a Turkish Airlines DC–10 cargo door blew out. The cabin floor and all hydraulic lines were severed. In 1979 an American Airlines DC–10 crashed in Chicago after a hydraulic failure, and at that time the FAA temporarily revoked the DC–10 certification.

Now, those are not the only such incidents, but there have been some incidents like this. Are you familiar with the DC–10 1974 Turkish Airlines situation?

Mr. WARREN. Yes.

Senator EXON. How would a cargo door cause all of the hydraulic systems to go?

Mr. WARREN. I am intimately familiar with that particular accident. I was in Paris, and I was in charge of a multimillion dollar test program done at Douglas to investigate all aspects of that after the accident.

The cargo door system—all cargo doors are a delicate part of an airplane from the stand point that the closing process needs to be done very well. The door in the case of the Paris accident, the aft cargo door, was not properly closed.

Certain safety systems that should have been installed on that airplane were not operational and, as a consequence, it was not clear to the flight crew that they had a hazardous situation.

What occurred then was that the door opened, and the mechanism is a little bit complicated, and I will try and make it simple. As the airplane decompressed, there was a differential pressure across the floor. It buckled the floor and jammed the control cables. This made it essentially impossible for the crew to maintain control of the airplane.

There were no hydraulic lines associated with that failure. The hydraulic system was entirely intact after that floor buckling situation. It was the operating cables to the valves that were stretched to the point that any motion of controls in the flight deck had no effect on the control surfaces of the airplane.

Senator EXON. So, if I understand what you are saying is that it is not accurate to say that there was a hydraulic failure in that Turkish incident?

Mr. WARREN. That is correct. There was no hydraulic failure involved.

A second point is associated with the Chicago accident. The question is was hydraulics involved in that accident. It is not cited in the NTSB report, and I think the NTSB report is very accurate.

What is said there is that some indication systems were not operational after the engine separated from the airplane.

As a consequence, the crew stalled the airplane because they did not have instrumentation to tell them that stall was imminent.

They flew the airplane for a significant time after the engine came off and if it would have been a hydraulic system failure, they very probably would not have been able to do that. And so, again, that is a case of misinformation.

The hydraulic system failure was not involved in the Chicago accident.

Senator EXON. Mr. Warren, thank you very much for being here. I have nothing further at this time, Mr. Chairman.

Senator FORD. Thank you, Senator Exon, and thank you, Mr. Warren.

I hope that the summation of this hearing today appears that all three of our witnesses from three major areas, the FAA, the National Transportation Safety Board, and McDonnell Douglas with the very astute gentleman, Mr. Warren, here testifying today that we have all been singing the same song.

Now, I hope that is correct, and I want to believe that it is. I hope that from this hearing and what is going on that we will continue to look at DC-10s and make the judgments that are necessary to improve its safety and that the task force that is being put together will be successful.

And I intend to monitor what goes on, and I intend to, I think, along with the members of the subcommittee, if we become dissatisfied with what is going on, that we will have another oversight hearing and bring that information to the public.

So, Mr. Warren, I appreciate your attendance here this morning.

Senator EXON. Mr. Chairman, before you close the record, let me say to Mr. Warren that not only that I see DC-3s being used up there exclusively in Canada, and they are still flying and doing a good job, but also the old C-46s that we used in World War II.

And, for the Chairman's information, I was only six and a half years old when I fought for my country in the South Pacific.

Senator FORD. I want you to know that he has mentioned three times his trip to Canada. He certainly was impressed, was he not.

Thank you, Mr. Warren, and we are going to leave the hearing record open until 5 on Friday.

If other Senators need to make a statement or any corrections of their statements and that sort of thing, the record will be held open until that time.

This hearing is dismissed.

[Whereupon, at 10:55 a.m., the subcommittee adjourned, subject to the call of the Chair.]

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